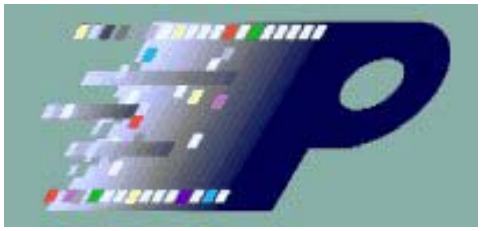

DPhyDecoderHSCtl User's Manual

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Documentation

1 Overview

The Moving Pixel Company DPhy Decoder HS is an instrument designed to monitor and decode traffic on up to 4 MIPI DPhy lanes running up to 2.5 Gbps. The instrument operates as stand-alone acquisition hardware for DPhy bus activity, and is used in conjunction with controlling software that also provides DSI, CSI-2, and DPhy protocol decode of acquired data.

The main functions of the DPhy Decoder HS hardware are to:

- Input and convert serial HS packet data to bytes
- Input and convert encoded LPDT and escape mode data to bytes
- Process DPhy data and package into records
- Provide DPhy, DSI, and CSI-2 protocol and state triggering for acquisition
- Store records into memory for acquisition
- Provide link activity indicators, status, and statistics including ECC error, CRC error, and HS burst error events.

The DPhy Decoder is controlled from a Windows application called DPhyDecoderHSCtl, which communicates with the Decoder via a USB connection. Using this application, the user can monitor DPhy bus activity, select modes of operation, configure the triggering and functions of the instrument, and initiate the acquisition and capture of DPhy traffic.

In addition, DPhyDecoderHSCtl provides post-processing and protocol disassembly of acquired data. For those familiar with Tektronix bus support packages that run on the instrument, the disassembly window of DPhyDecoderHSCtl has a similar look-and-feel. However, extensive improvements have been made to the basic listing functionality, providing sophisticated functions for displaying, filtering, and searching captured data. This includes a packet type summary listing of all packet types in the acquired trace. It also includes a video frame summary listing that provides statistics, navigation, viewing, and saving of video frames to files.

The DPhy Decoder HS is a successor instrument to the DPhy Decoder and has several improvements over its predecessor:

DPhy Decoder HS	**DPhy Decoder**
Supports up to four lanes @ 2.5 Gbps	Supports up to four lanes @ 1.5 Gbps
Supports DPhy, DSI, CSI-2 version 1.2	Supports DPhy, DSI, CSI-2 version 1.1
Intended to be upgradable for DSI 2.0	Not upgradable
1 GB acquisition memory	512 MB acquisition memory
Efficient, lane-independent data storage (50% effective data packing)	Per-lane data storage (33% effective data packing at 4 lanes with timestamps)
Supports "Monitor Mode" operation using solder-down probes	Supports "Monitor Mode" operation using solder-down probes
Supports new "Receive Mode" operation	No support for "Receive Mode" operation

using SMA inputs (includes termination control and simple configurable BTA response packet)	

,

2 Setup & Installation

The DPhyDecoderHSCtl application should be installed on a Windows host machine with the following requirements:

- **Operating System**: the host machine should be running WinXP, Win7, or Win8, using either a 32-bit or 64-bit processor.
- **Communication**: USB3 or USB2. The application communicates with the DPhyDecoderHS instrument through USB. USB3 is greatly preferred for its increased performance.
- **Memory**: at least 4 GB. As DPhyDecoderHSCtl is memory and processing intensive, more memory is advantageous.

To install DPhyDecoderHSCtl, simply execute the setup.exe file provided and step through the installation windows. The DPhyDecoderHSCtl application is installed by default in the **c:\Program Files\TMPC\DPhyDecoderHSCtl** directory.

One the application is installed, set up connections to your DPhy Decoder HS instrument and start up as follows:

- Connect a USB2 or USB3 cable between the host computer and instrument
- Connect your DUT to either the SMA inputs (Receive Mode) or high-impedance, solder in inputs (Monitor Mode).
- Plug in and connect the 24V power adaptor
- Power on the instrument
- Launch DPhyDecoderHSCtl application.

3 DPhy Decoder HS Concepts

3.1 Data Records

The main function of the DPhy Decoder HS hardware is to monitor up to four lanes of DPhy bus traffic and package data into records for acquisition and display. All facets of bus communication are captured from lane LP signaling to escape mode sequences to LPDT and HS burst packets.

Depending on the current DPhy bus state, one of two types of data records are internally generated and stored. The exact details are not important to the user in normal use, but a quick overview may be helpful to understanding other operational concepts.

Basically, if one or more lanes are transmitting data in an HS burst, then HS data records containing packed and acquired lane data are generated. Otherwise, LP data records are generated, containing the LP state of all lanes and a timestamp. Both record types have associated status that conveys auxiliary state information about the record including various header flags, trigger information, etc.

In general, LP data records are output only when one or more lanes change LP state. This significantly compresses the record set captured by the instrument and compacts the disassembly view. As timestamps can indicate duration in a particular LP state, duplicated records is not necessary.

There is one reason to duplicate records, however. In particular, when bus activity is nearly idle then it is possible for the processing pipeline to stall and acquisition memory never to fill completely. To handle this case, a control is provided ("Idle Timeout") to specify an idle timeout period that forces duplicate LP records into the processing pipeline.

3.2 Escape Mode

A mode commonly enabled in the application is called "Escape Mode". This mode translates and replaces LP records that convey escape packets with higher-level protocol records for triggering and display. If not enabled, escape-packet triggering and decoding (including LPDT packets) is not supported. On the other hand, disabling "Escape Mode" does allow low-level LP edge transitions and timing to be seen if necessary for low-level debugging.

3.3 Receive Mode

Another mode option is called "Receive Mode".[1] When enabled, the instrument uses the SMA input connectors as lane inputs, which are actively terminated according to the DPhy protocol during HS bursts. In addition, the user can specify a short response packet and return BTA (or other LP signaling response) to be transmitted when the DUT sends a

[1] Receive Mode and Escape Mode are not exclusive and can be independently enabled/disabled.

BTA. When "Receive Mode" is not enabled, the instrument operates in "Monitor Mode" (also referred to as "Sniff Mode") using the instrument's solder-down probe high-impedance inputs. In this mode, no lane terminations or BTA response packet support are provided.

3.4 Triggering

Triggering is the process of completing acquisition based on trigger criteria specified by the user. Once the specified criteria are met, the instrument fills up memory with data records. Note that even after acquisition has started, trigger criteria continues to be evaluated and the result is associated with data records for subsequent search and display. Thus, while there is only one trigger record (i.e. one record that triggered acquisition) there is no restriction on the number of records that may have their trigger flag set.

The term "Prefill" is used to describe records in an acquisition preceding the trigger record. Often, users want to see bus activity leading up to the trigger condition as much as activity that follows it. A user control for prefill is available allowing 5% to 95% of the acquisition to precede the trigger record.

In general, the prefill requirement must be met before a record satisfying the trigger criteria is considered. This means that one or more records with their trigger bit set may not trigger acquisition. In some cases this is not desirable as the trigger condition only occurs once in a test. To allow successful acquisition in this case, an option is provided ("Allow Trigger Before Prefill") that ignores the prefill requirement for triggering if necessary.

In the DPhy Decoder HS, various trigger modes are supported. Simple modes such as triggering "Immediately" or on an error condition such as CRC error, ECC error or burst don't require any further configuration. Other modes require the user to define predicate terms that are then used in an arbitrary Boolean trigger equation. Often this equation is simply an ANDing or ORing of predicate terms.

A common form of triggering is based on packet data, where predicate terms are built from comparing masked fields in DSI/CSI packets and compared to constants. Other trigger modes use LP Signal State, lane-zero LP Sequence State (e.g. BTA), or the lane-zero Escape command to build their predicates.

4 Using DPhyDecoderHSCtl

4.1 Connecting to the Instrument

When the application is started, a connection dialog (see Figure 1) is shown for the user to select a DPhy Decoder instrument powered-on and reachable via USB. This dialog can also be brought up for the user to switch instruments using the option in the Control menu labeled "Connect to DPhy Decoder...".

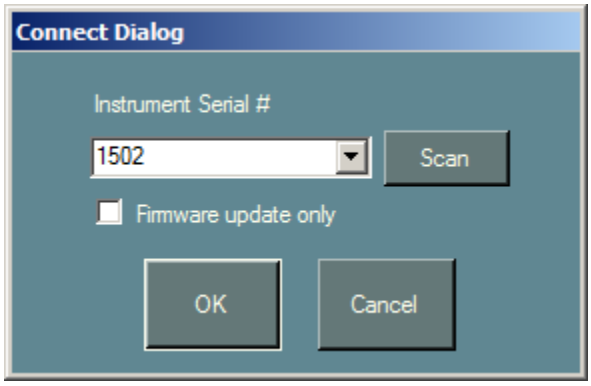

Figure 1 – Connection Dialog

A drop-down control is provided with reachable instrument serial numbers as well as an option called "Offline". Offline mode allows using the application to be used without a connection to real hardware, useful for demonstration of the GUI, testing remote-control applications, and viewing saved disassembly traces. Clicking the "Scan" button updates the instrument serial number control, adding any new instruments that have recently been powered on.

Note that while multiple copies of the application can run at the same time, only one instance can be connected to a given instrument at a time. Serial numbers of instruments that are in-use by another copy of the application are marked "(in use)".

To connect to an instrument, simple select the appropriate serial number and click OK. Note that the serial number and firmware version of the currently connected instrument appears in the status bar at the bottom-right of the main window.

Shutting down the application will automatically disconnect from the instrument. The user can explicitly disconnect using the "Disconnect from DPhy Decoder" menu option in the Control menu, leaving the application offline.

4.2 Main Window

Once connected, the main window is shown (see Figure 2). The instrument serial number is shown in a bottom right pane on the status bar. The main window contains all the user-controls for configuring and operating the instrument.

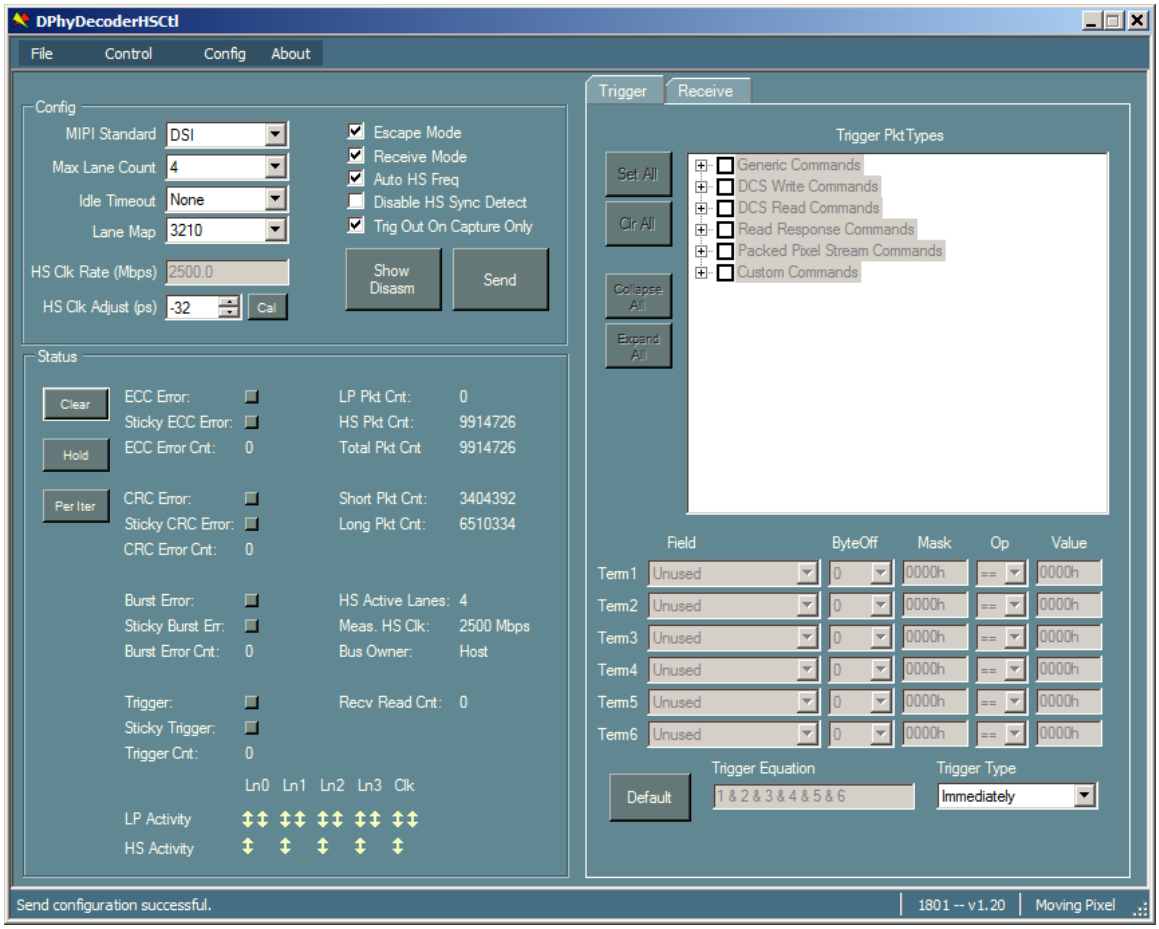

Figure 2 – DPhyDecoderHSCtl Main Window

The main window is divided into four areas of controls: configuration, status, trigger control, and receive control (the last two share a tabbed page). The following sections describe each of these areas.

4.2.1 Configuration Controls

The section of the main window provides controls that support overall mode configuration and are located in the upper-left section of the main window. They are:

MIPI Standard – drop-down control to select the DSI or CSI standard. This selection should be made first as it naturally resets the filtering and triggering options available to the user.

Max Lane Count – drop-down control to select the maximum number of lanes to monitor for activity. Unused lanes are forced to LP11 for the purposes of instrument monitoring and acquisition. The instrument monitors DPhy bus activity on lane counts up to the Max Lane Count setting. For example, with a Max Lane Count setting of 3, HS bursts using 1, 2, or 3 lanes will be detected automatically and the actual number of lanes participating in ongoing HS bursts is displayed in the status region.

Idle Timeout – drop-down control to set the idle time-out duration. This setting is the maximum time to wait without outputting a record before inserting a duplicate LP record into the processing pipeline. If timeout is set to "None", the instrument will wait indefinitely for a change in input state, stalling the processing pipeline and possibly preventing detection of last active records in a trace.

Escape Mode – check box to enable escape-mode protocol detection and escape packet reconstruction, necessary for triggering and presentation of escape packets (including LPDT packets). Note that if escape-mode is not enabled, triggering on escape packets is not supported and only low-level LP state transitions are displayed for escape packets in the disassembly listing.

Receive Mode – check box to enable receive-mode operation. If checked, the instrument connects to the SMA inputs as a true receiver, enabling/disabling lane terminations during HS bursts according to the DPhy protocol. In addition, in this mode, the user can configure a single short LPDT response packet and/or other LP signaling to transmit on lane 0 whenever a BTA is seen on the bus. If not checked, the instrument operates in monitor-mode (also called sniff-mode) using the high-impedance solder-in probe inputs.

Disable HS Sync Detect – check-box to disable HS sync detection during input processing, triggering, and disassembly. Generally, this is used only for low-level debugging and phy-level testing with non-protocol data traffic on the DPhy bus. Checking this option disables protocol-level testing and thus the flagging of protocol errors (and protocol statistics).

Trig Out On Capture Only – check-box to set the output mode of the "Trig Out" signal of the instrument. If checked, the "Trig Out" signal pulses high only for the trigger condition that causes acquisition. If unchecked, the "Trig Out" signal pulses high whenever trigger conditions are met in the stream, whether or not the trigger causes acquisition. Note that the "Trig Out" pulse duration is about 160 ns and retriggers within that time lengthen the pulse accordingly.

Lane Map – drop-down control to configure a logical-to-physical mapping of data lanes connected to the instrument. Each digit in the four-digit value selected represents a logical lane assignment. Each position in the four-digit value represents a physical lane connector (starting with lane 3 down to lane 0). Thus, the default setting of "3210" represents a unity mapping of logical lane to physical lane connector. Setting the map value to "0123", on the other hand, will decode the lane 3 connector as lane 0, lane 2 connector as lane 1, etc.

Note that there are some restrictive caveats associated with using a non-standard lane mapping. In particular, physical lane 0 must participate in HS bursts for such traffic to be decoded properly. For example, if physical lane 0 is used as logical lane 2, then only 3-lane and 4-lane HS bursts will be decoded properly. If used as logical lane 3, then only 4-lane HS bursts will be decoded properly.

Another caveat is in Receive Mode, where read response traffic is always output on physical lane 0 regardless of lane mapping. Thus, effectively, Receive Mode responses are only useful if logical lane 0 is mapped to physical lane 0 in the lane mapping.

Auto HS Freq – check box to enable the instrument to automatically detect the clock lane frequency. When checked, the HS Clk Rate text box is disabled and automatically filled in with the detected clock lane bit rate.

This mode is very useful and should work correctly for legal DPhy traffic. However, there may be situations where non-conforming traffic patterns cause incorrect or erratic clock frequency detection. In these cases, the user should disable "Auto HS Freq" and manually enter the HS Clk Rate.

When this mode is enabled and the detected bit rate changes more than +/- 10%, this causes software to automatically resynchronize the hardware using the new bit rate. In this case, there may be a brief period when errors are detected before the frequency and sampling phase change is completed. Thus, as a convenience, all statistics are reset when a significant clock change is detected.

HS Clk Rate – text box to indicate the detected clock lane bit rate during HS bursts. This value is used to set the sampling phase of the data relative to the clock on input. Its accuracy becomes more important with increasing frequency, given the smaller valid sampling windows. Generally, if possible, it is best to use auto-detection (via Auto HS Freq) to set this value.

HS Clk Adjust – up/down control to adjust fine delay timing on the incoming HS Clk for high-frequency acquisitions. This timing control adjusts the clock *relative to the ideal quadrature setting* for acquisition and, normally, this value should thus be set to zero. However, modest adjustments are sometimes required depending on less-than-ideal acquisition conditions depending on input signal integrity, non-standard voltages, cabling, noise, or timing skew on the bus.

Cal – button to automate finding an optimal HS Clk Adjust setting by sweeping a delay range. This procedure requires valid HS traffic to be continually streaming on the bus as the valid clock window is validated using the detected ECC and CRC error count. To use, simply click this button to initiate a sweep search within approximately +/- one bit period around the ideal quadrature setting small increments, measuring the number of ECC and CRC errors received in a short time period. The sweep takes a few seconds and when complete, the optimum HS Clk adjustment setting is displayed and assigned to the control.

Show Disasm – button to bring up the disassembly window for acquisition.

Send – button to send the current configuration (including trigger settings) to hardware and reset the status display. In particular, this is required operation to update changes made in the trigger configuration controls, but otherwise is not necessary for most other

configuration controls (as these controls send new values automatically to hardware when changed). The user is notified that the Send button should be clicked by the appearance of the text "Modified" to the lower-right of the Send button.

Note: as this process also resets the instrument input logic, this button should also be used if the hardware gets into a bad state. One possiblity in DSI is if the instrument might see traffic that causes it to incorrectly believe the DPhy bus owner is the device and not the host. Resetting the hardware restores the bus owner flag in the instrument to "Host".

4.2.2 Trigger Tab Page Controls

The trigger tab page is one of two tab pages occupying the right side of the main window. To show the page, click on the Trigger tab at the top.

As mentioned in section 3.4, the DPhy Decoder has several triggering modes. The triggering mode is selected via the Trigger Type drop-down control at the bottom-right corner of the Trigger Controls section. The trigger mode should be selected first before other fields as the control options change based on mode. The trigger modes available are:

- **Packet Fields** – This is a common form of triggering. In this trigger mode, the user defines predicate terms based on packet fields and a trigger equation to evaluate and combine terms to determine the final trigger condition. Predicate terms perform Boolean comparisons between packet fields and constant values.
- **LP Signal State** – Compares LP signal state for any or all lanes (including the clock lane) as predicates evaluated in a Boolean equation to determine trigger state.
- **LP Sequence State** – Evaluates the lane zero sequence state (e.g. BTA) as predicates evaluated in a Boolean equation to determine trigger state.
- **Escape Command** – Compares escape command bytes as predicates evaluated in a Boolean equation to determine trigger state.
- **Skew Calibration** – Sets the trigger flag on a skew calibration burst.
- **CRC Error** – Sets the trigger flag on a packet CRC error.
- **ECC Error** – Sets the trigger flag on a packet ECC error.
- **Burst Error** – Sets the trigger flag on an HS burst error, which occurs when valid HS Sync bytes for all active lanes in an HS burst cannot be synchronously detected.
- **Any Error** – Sets the trigger flag on any error (CRC error, ECC error, or burst error).
- **Immediately** – This mode causes immediate triggering once the Run button is clicked.

4.2.2.1 Packet Fields Triggering

When triggering based on packet fields, triggering is a two stage process. The first stage selects the set of packets based on packet type for further evaluation.[2] The second stage then evaluates these qualifying packets using the designated predicate terms and trigger equation to determine the trigger flag state.

4.2.2.1.1 Stage 1 Trigger Selection

The first stage selection process of packets for trigger evaluation uses the Trigger Pkt Types which is a checked tree-view containing all packet types. Top-level nodes in the tree-view consist of categories of packet types and second-level nodes in the tree-view represent the packet types themselves. Category nodes are not able to be checked by the user, but they are checked by software to show that at least one sub-node within the category is checked.

To select a packet type to be included in trigger evaluation, the user simply opens the tree node category (if closed) and checks the desired packet type. Note that in this mode, if no packets are selected, *no trigger will result*, regardless of the trigger equation settings.

For DSI, the top-level categories are:

- Generic Commands
- DCS Write Commands
- DCS Read Commands
- Read Response Commands
- Packed Pixel Stream Commands
- Custom Commands

For CSI, the top-level categories are:

- Generic Commands
- YUV Commands
- RGB Commands
- Raw Commands
- User Commands
- Custom Commands

These categories are mostly self-explanatory, based on the packet type definitions for each respective MIPI specification. The Generic Commands category includes all packet types defined in the specification that do not fall in any of the other categories. The Custom Commands category includes user-defined data types using the Custom Command dialog (Config -> Define Custom Commands… menu option).

Other button controls in this section are:

[2] Note that both HS packets and LPDT packets are considered for triggering in this mode, but only if Escape Mode is enabled. Otherwise only HS packets are considered.

Set All – checks all the packet types in the tree-view

Clr All – clears all the checked packet types in the tree-view

Collapse All – collapses all the category nodes in the tree-view

Expand All – expands all the category nodes in the tree-view

4.2.2.1.2 Stage 2 Trigger Selection

Stage-two trigger selection defines the predicates and the trigger equation to be used for final trigger evaluation. Six predicate terms are supported where each term targets a 16-bit field (byte aligned) starting at any starting byte offset between 0-10. This byte range allow all fields in short packets and long DCS packets with up to three 16-bit arguments to be fully supported. Predicates are defined by masking the field and comparing it to a value. After the predicate terms have been defined, the user specifies a logical trigger equation that uses the field comparison results.

The following list describes the controls used for each term definition:

- **Field** – drop-down control identifying some common pre-defined field names. Full use of this control is not required, as most entries simply act as a "preset" for other controls in the term. The user can always just select "Custom" to have full control over predicate definition (see below). Note that when defining a predicate, the Field value should be selected first, as it will overwrite the other term controls with appropriate values.

  The first option is always "Unused" which sets the term controls to an always true comparison. This allows it to be included in the default trigger equation (all terms ANDed) with no effect. This selection is merely a convenience for readability because the trigger equation actually specifies whether a term is used or not and, thus, it is not necessary to set unused terms to this setting.

  The second option in the field drop-down control is always "Custom", which enables all the other term controls for arbitrary user settings.

  Next, follow common generic packet header fields (i.e. VC, DataType, DataID, WordCount, ECC) which initialize the byte offset and mask fields appropriately, allowing the user to set the comparison operation and value for the term.

  Finally, additional options may be added to the Field control list, varying with the selected packet type. If a single packet type with known fields is selected in stage 1, then they are added as options here.
- **ByteOff** – drop-down control to set the byte offset of the field. For example, a byte offset of 4 would specify the field to be the first two payload bytes of a packet. (Note in this case that all of the selected packets from stage 1 should be long packets as byte 4 is not defined for short packets.).
- **Mask** – text box to set the mask value. This value is treated as a 16-bit value and ANDed with the packet field before comparison with the term value. Values are parsed as decimal unless appended with an 'h', in which case they are parsed as

hexadecimal (i.e. 20h = 32 decimal). The LSB corresponds to the earlier byte in the packet. For example, if the mask were set to FF00h with ByteOff == 4, the resulting masked value would have packet byte 5 in the MSB and zero in the LSB.

- **Op** – drop-down control to select the predicate comparison operation. All logical comparisons are supported, i.e. ==, !=, >, >=, <, <=.
- **Value** – text-box to set the term comparison value. Values are parsed as 16-bit decimal numbers unless appended with an 'h', in which case they are parsed as 16-bit hexadecimal (i.e. 20h = 32 decimal). As with the mask value, the LSB represents the earlier packet byte.

The final controls used for stage two triggering are the trigger equation specification itself and the default button:

- **Trigger Equation** – text box to specify how term predicates should be combined in a Boolean equation to determine the final trigger state. Terms predicates are identified using the numbers '1' through '6'. The '&' and '|' symbols for AND and OR operations and parentheses can be used to set precedence (e.g. "1 & (2 | 3) & 4").
- **Default** – button to reset all term controls and the trigger equation to their default. The default setting is for all term controls to be "Unused" and the trigger equation to be "1 & 2 & 3 & 4 & 5 & 6".

4.2.2.2 LP Signal State Triggering

When triggering based on LP Signal State, the packet field controls are disabled and triggering is solely determined by predicate term and trigger equation definition.[3] Please refer to section 4.2.2.1.2 for an overview of these controls.

The main difference in this mode versus packet field triggering is that predicate terms always operate on a composite value derived from LP records (rather than fields within a packet). This composite value is 10 bits and indicates the current LP state of all lanes including the clock lane. The five 2-bit fields represent the LP state of each lane, where 0 = LP00, 1 == LP01, 2 == LP10, and 3 == LP11.

Bit definitions for the fields are as follows:

- [1:0] lane 0 LP state
- [3:2] lane 1 LP state
- [5:4] lane 2 LP state
- [7:6] lane 3 LP state
- [9:8] clock LP state

For example, a mask of 0x300 and a value of 0x100 define a predicate to test if the clock lane is in the LP01 state.

[3] Note that in this mode, if all terms are set to "Unused, triggering is disabled.

For convenience, the field drop-down control in this mode contains entries for all combinations of lane and state, i.e. "Lane0 in LP00", "Lane0 in LP01"... "Clock in LP10", "Clock in LP11". Also, note that the ByteOff field is unused in this mode and is thus disabled.

4.2.2.3 LP Sequence State Triggering

When triggering based on LP Sequence State, the packet field controls are disabled and triggering is solely determined by predicate term and trigger equation definition.[3] Please refer to section 4.2.2.1.2 for an overview of these controls.

The main difference in this mode versus packet field triggering is that predicate terms always operate on the lane zero sequence state. DPhy defines various LP signaling sequences such as BTA, ESCAPE, and HS and triggering is possible on the occurrence of any of them. While each state and intermediate states are represented by a particular field value, only a few are generally useful. These particular states – "HS Burst", "BTA", "BTA Exit" and "Escape Entry" – are available for convenience in the field drop-down control.

For completeness, Table 1 documents all the possible sequence states. Numbers in the state names indicate receipt of a particular LP signal value (i.e. 0 = LP00, 1 = LP01, 2 = LP10, 3 = LP11). For example, if the sequence state is LPSTATE_3, lane 0 is currently in the LP11 state. If in LPSTATE_32, lane 0 has seen LP11 followed by LP10.

Table 1 – Lane 0 Sequence States

State	Value
LPSTATE_UNKNOWN	0
LPSTATE_3	1
LPSTATE_32	2
LPSTATE_320	3
LPSTATE_3202	4
LPSTATE_BTA	5
LPSTATE_BTA_EXIT	6
LPSTATE_3201	7
LPSTATE_ESCAPE	10
LPSTATE_31	11
LPSTATE_HS	12

4.2.2.4 Escape Command Triggering

When triggering based on the Escape Command, the packet field controls are disabled and triggering is solely determined by predicate term and trigger equation definition.[3] Please refer to section 4.2.2.1.2 for an overview of these controls.

The main difference in this mode versus packet field triggering is that predicate terms only are applied to escape command byte values.

For convenience, the field drop-down control in this mode contains entries for predefined escape commands in the DPhy specification. These are: "LPDT", "ULPS", "Reset Trigger", "Trigger 1", "Trigger 2", and "Trigger 3". The user may also select "Custom Escape Cmd" to define other command values.

4.2.2.5 Skew Calibration Triggering

When triggering on Skew Calibration, all other trigger controls are disabled. The trigger flag is set for bursts that contain a skew calibration sequence.

4.2.2.6 CRC Error Triggering

When triggering on CRC errors, all other trigger controls are disabled. The trigger flag is set for packets that have a CRC error.

4.2.2.7 ECC Error Triggering

When triggering on ECC errors, all other trigger controls are disabled. The trigger flag is set for packets that have an ECC error.

4.2.2.8 Burst Error Triggering

When triggering on burst errors, all other trigger controls are disabled. The trigger flag is set for packets that have a burst error which is defined as when either:

1) A valid HS burst entry and exit sequence is seen on a lane but with no valid sync byte
2) A valid HS burst entry and exit sequence is seen on multiple lanes but sync bytes, if present, are not within one byte time of each other.

When a burst error is declared in the disassembly, a single burst error packet is shown containing unaligned data for all active lanes.

4.2.2.9 Any Error Triggering

When triggering on any errors, all other trigger controls are disabled. The trigger flag is set for packets that have a burst error, ECC error, or CRC error.

4.2.2.10 Trigger Immediately

When triggering immediately, acquisition begins immediately after the Run button is clicked. The trigger flag is not set for any packet.

4.2.3 Receive Tab Page Controls

The receive control page is one of two tab pages occupying the right side of the main window. To show the page, click on the Receive tab at the top.

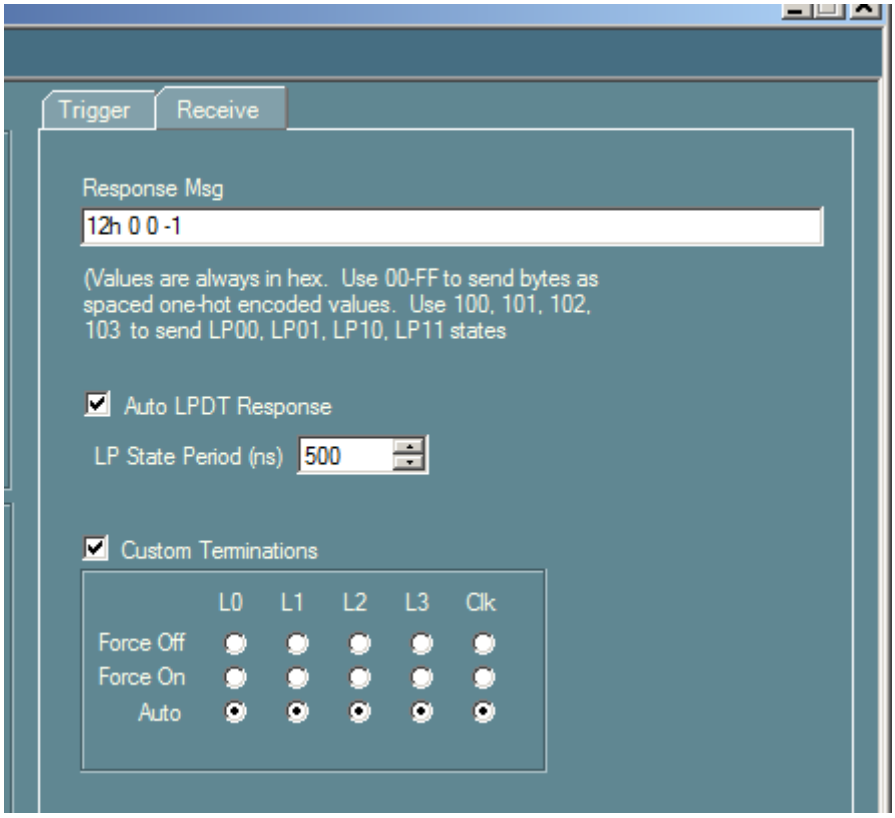

Figure 3 – Receive Controls

Receive controls only apply when the instrument is in receive-mode (i.e. the "Receive Mode" check-box in the main window configuration pane is checked). These controls (see Figure 3 – Receive ControlsFigure 3) configure two behaviors in receive-mode:

1. How the instrument responds to an incoming BTA on the bus. The user can define up to a 128 LP-transition sequence using the Response Msg text box that is transmitted whenever a BTA is received. The following transmit rules are used:
   - Values are always treated as hexadecimal, e.g 100 => 0x100
   - Values between 00 and FF inclusive are treated as hex bytes to send as Spaced One-Hot coded LP transitions (each byte requires 16 LP transitions).
   - Values between 100 and 103 inclusive are treated as individual LP states to transmit, with 100 corresponding to LP00, 101 corresponding to LP01, etc.
   - A value of -1 can be used in the ECC byte position for automatic calculation of the ECC value.
   - The period of each LP state transmitted is determined by the LP State Period control setting (truncated to the nearest 5 ns).

- If "Auto LPDT Response" is checked, pre- and post- signaling for an LPDT packet response will be automatically sent (see Auto LPDT Response control description below).

2. How the instrument terminates lanes (SMA inputs only). Basically, the user can force each lane's termination on/off or allow the instrument to turn on termination automatically during HS bursts as according to the DPhy specification (see Custom Terminations control description below).

The following describes the receive-mode controls:

- **Response Msg** – text box describing the response sequence to transmit on lane 0 after receiving a BTA. The user provides a list of integer values in the text box, separated by spaces, controlling the LP signal states that are transmitted. See rules above for values in list. For example, a read-response packet could be sent using the string "12 0 0 -1".
- **Auto LPDT Response** – check-box that indicates the response is intended to be an LPDT command (common case). When enabled and a BTA is received on the bus, the instrument will automatically send the BTA acknowledge sequence (LP10 LP11) followed by the escape-entry sequence and LPDT escape command before the user-defined sequence is sent. In addition, following the user-defined sequence, a return BTA is automatically sent. If Auto-LPDT response is not checked, the user must provide all LP signaling and spaced one-hot data (if desired)
- **LP State Period** – up/down control to set the duration of each transmitted LP state. When used, the value is truncated to the nearest 5 ns boundary. Generally, this should be set to the DUT's T(LPX) period for proper BTA handshaking.
- **Custom Terminations** – check-box to enable custom terminations settings. When enabled, controls to force terminations on/off for each lane are enabled as well as controls to select "Auto", which enable normal HS burst termination behavior. When the check-box is disabled, "Auto" termination mode is set for all lanes.

4.2.4 Status Controls

When connected to a DPhy Decoder HS instrument, the status control section provides continuously updated statistics about bus activity monitored by the instrument. Status updates occur about once a second.

The status display generally falls into three categories: activity, statistics, and statistics control.

4.2.4.1 Activity

The activity display at the bottom of the status pane shows graphically the LP and HS activity occurring on each lane. The following notes describe the activity display:

- Activity for the LP+, LP-, and HS signals or each lane is represented by an indicator graphic.
- The top row for LP activity consists of 10 indicators, a pair for each lane, with the left indicator in each pair representing LP+ and the right indicator representing LP-.
- The bottom row for HS activity consists of 5 indicators, one for each lane.
- Indicators can be low (low horizontal bar), high (high horizontal bar), or transitioning (vertical bar with arrows on both ends).
- The indication spans the period since the last status update, so for example, if a toggling indicator appears, it means that the signal transitioned at least once since the last update.
- Indicators are valid and updated even if the acquisition pipeline is stalled waiting for an event (i.e. instrument Output is inactive -- for example, while in delta mode with no timeout and a quiescent bus).

4.2.4.2 Statistics

The predominant part of the status control section consists of on-going, real-time statistics about data traffic on the DPhy bus. Each statistic is summarized below:

The ECC byte in packet headers check the integrity of the packet header. The ECC is tested for packets sent in both HS and LPDT mode if Escape Mode is enabled. Otherwise, the ECC is tested (and errors can be triggered on) only in HS packets. Controls and statistics relating to ECC status are:

- **ECC Error** – LED-control indicating whether an ECC error occurred since the last update. If red, an error occurred; if green, no error occurred.
- **Sticky ECC Error** – LED-control indicated whether an ECC error occurred since the last clear event. If red, an error occurred; if green, no error occurred.
- **ECC Error Cnt** – counts the number of ECC errors that occurred since the last clear event.[4]

The CRC bytes at the end of long packets check the integrity of the packet payload for long packets. The CRC is tested for packets sent in both HS and LPDT mode if Escape Mode is enabled. Otherwise, the CRC is tested (and errors can be triggered on) only in HS packets. Controls and statistics relating to CRC status are:

- **CRC Error** – LED-control indicating whether a CRC error occurred since the last update. If red, an error occurred; if green, no error occurred.
- **Sticky CRC Error** – LED-control indicated whether a CRC error occurred since the last clear event. If red, an error occurred; if green, no error occurred.

[4] Note when any of the ECC, CRC, or Trigger counts reach 999 million, they are all reset to zero and continue counting.

- **CRC Error Cnt** – counts the number of CRC errors that occurred since the last clear event.[4]

A burst error is declared when the instrument cannot find an HS sync byte in all active lanes of an HS burst occurring "nearly" synchronous to each other. In this case, the instrument cannot decode or trigger on packets in the burst. Controls and statistics relating to burst error are:

- **Burst Error** – LED-control indicating whether a burst error occurred since the last update. If red, an error occurred; if green, no error occurred.
- **Sticky Burst Err** – LED-control indicated whether a burst error occurred since the last clear event. If red, an error occurred; if green, no error occurred.
- **Burst Error Cnt** – counts the number of burst errors that occurred since the last clear event.[4]

The trigger flag is set whenever the conditions defined by the trigger controls are met. Controls and statistics relating to trigger status are:

- **Trigger** – LED-control indicating whether a trigger event occurred since the last update. If light blue, a trigger occurred; if green, no trigger occurred.
- **Sticky Trigger** – LED-control indicated whether a trigger event occurred since the last clear event. If light blue, a trigger event occurred; if green, no trigger occurred.
- **Trigger Cnt** – counts the number of trigger events that occurred since the last clear event.[4]

Packet count statistics summarize the number of occurrences of each type of packet.[5] Statistics relating to packet counts are:

- **Short Pkt Cnt** – counts the number of short packets since the last clear event.
- **Long Pkt Cnt** – counts the number of long packets since the last clear event.
- **LP Pkt Cnt** – counts the number of LS packets since the last clear event.
- **HS Pkt Cnt** – counts the number of HS packets since the last clear event.
- **Total Pkt Cnt** – counts the total number of packets since the last clear event.

Lastly, other miscellaneous statistics provided are:

- **HS Active Lanes** – Indicates the maximum number of lanes that were part of an active HS burst since the last clear event. If zero, no HS packets were seen.

[5] Note when any of these packet counts reach 999 million, all counts reset to zero and continue counting.

- **Meas. HSClk** – Indicates the measured HS clock over a relatively short time period (milliseconds). If "Auto HS Freq" is checked, this measurement is used to update the "HS Clk Rate" setting (if it differs by more than 10%).
- **Bus Owner** – Indicates the current owner of the DPhy bus (**Host** or **Device).** It is possible for this state to be incorrect, for example, if the instrument or devices are powered on or reset when the DUT owns the bus (or if invalid LP traffic is seen). Please verify that the indicator is correct before starting an acquisition or if ongoing unexpected errors are seen. Pressing the Send button causes the bus owner to be reset to Host
- **Recv Read Cnt** – Indicates the number of BTA cycles seen since the last clear event.

4.2.4.3 Statistics Control

Three buttons control how statistics are displayed:

- **Clear** – resets all statistics to zero. The clear function is also automatically applied when the Send button is pressed or when in Auto HS Freq and the detected frequency changes by more than 10 MHz.
- **Hold / Resume** – suspends or resumes statistics update. The button label alternates with each click, indicating the function to be performed when next pressed. For example, when "Resume" is displayed, statistics update is halted until the button is pressed.
- **Totals / Per Iter** – shows total counts or per update counts. The button label alternates with each click, indicating the function to be performed when next pressed. For example, when "Totals" is displayed, all statistics except for the sticky errors and trigger, summarize activity only since the last update (rather than since the last clear).

4.3 Disassembly Window

The disassembly window uploads, decodes, and displays captured records from the DPhy Decoder instrument. This window can be brought up from the main window by clicking on the "Show Disasm" button in the Trigger pane (center screen).

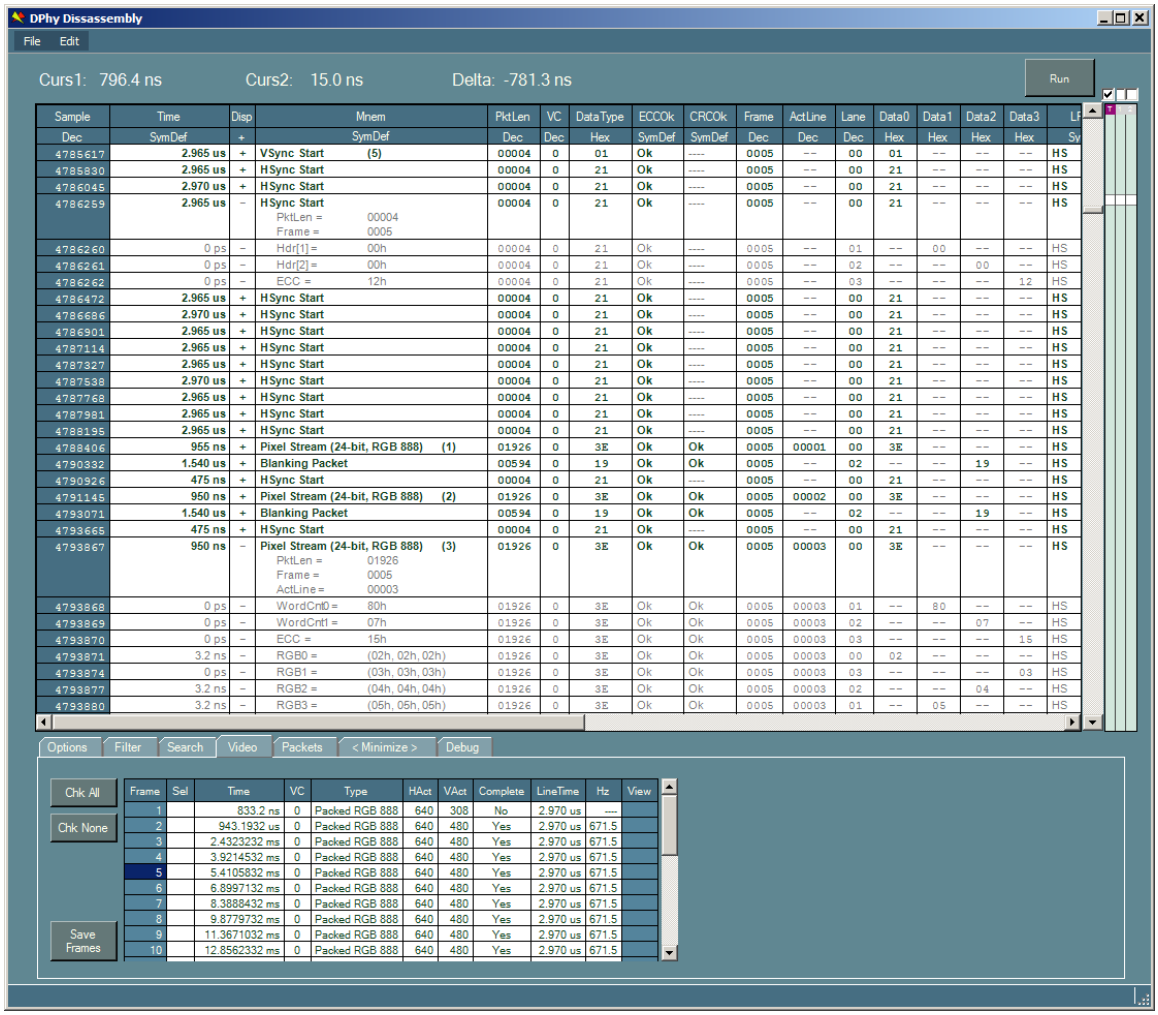

Figure 4 – Disassembly Window

Figure 4 shows a disassembly listing showing the capture of a DSI video sequence. The control areas of the disassembly window can be broken down as follows:

- **Run/Stop Button** – This button at the top-right of the window controls the start of acquisition. It can force a trigger if desired and can also be used to abort long processing tasks. Depending on the current processing state, its name may display "Run", "Stop", or "Abort".
- **Listing Grid** – The listing grid is the central feature of the disassembly window. It contains decoded records and their fields.
- **Cursor Status Display** – The top part of the window shows a text read-out of the two cursor locations (time relative to start of trace). The time delta between the two cursors is also displayed. In addition, if one or more disassembly rows are selected, the total time for the selected rows is displayed.
- **Cursor Control Panel** – The cursor panel is a control next to the vertical scroll bar of the listing grid (far right) that spatially indicates relevant locations in the trace, specifically: trigger location, cursor locations, and current view location.

- **Disassembly Control Panel** – The tabbed control beneath the listing grid contains all the controls associated with disassembly. Separate tab pages provide controls for acquisition and disassembly options, filtering and searching disassembly records, and the display of video frame and packet information contained in the trace capture.

4.3.1 Run/Stop Button

When the DPhy Decoder is connected and monitoring activity on a DPhy bus, clicking the Run button initiates an acquisition. Acquisition is configured via the Options tab page of the disassembly control panel, in particular, how much memory to use and where the trigger should occur relative to records in the trace (see section 4.3.4.1).

The acquisition process has several phases:

- **Prefill** – memory is "prefilled" with data records before the trigger criteria are evaluated. This allows placement of the initial trigger record position in the overall trace capture (e.g. at the start, in the middle, near the end, etc).

- **Trigger** – trigger criteria are evaluated. While waiting for the trigger condition to evaluate true, prefill records continue to be acquired, discarding the oldest captured records to make room for new records. During this time, the status displayed in the status bar will be "Waiting for trigger…". Also, the label of the Run button will change to "Stop". Clicking the Stop button will force a trigger condition, moving the process to the next phase (Capture).
- **Capture** – capture memory is filled with data records. During this time, the status displayed in the status bar will be "Waiting for capture buffer to fill…". In some capture configurations (e.g. if "Idle Timeout" is zero and quiescent lane activity), it is possible for acquisition to stall waiting for data. In this case, the user can click the "Stop" button to complete acquisition with the records that have been captured. Be aware that this will leave some valid data un-captured in the processing pipeline (set "Idle Timeout" to ensure a complete capture).
- **Upload** – capture memory is uploaded from the DPhy Decoder instrument into application memory. Upload speeds for USB2 are about 20 MB/s and up to 10x faster for USB3. During this phase, the Run button label will be set to "Abort" . Clicking the Abort button halts upload and discards any partially uploaded data.
- **Decode** – captured records are decoded and displayed in the listing grid. Generally, this is a fairly quick process, though depending on the filter and disassembly settings, record content, and the number of captured records, this can take some time. Progress is indicated via the status bar, with "Building records…" and a percent complete. The Run button label remains set to "Abort" for the user to request a halt to decoding. If aborted, partial results are displayed.[6]

[6] In the event that the user wants to obtain a full decoding after aborting, clicking the "Reanalyze" button in the Options tab reinitiates decoding.

4.3.2 Listing Grid

The listing grid displays one disassembly record per line, arranged in order from earliest in time at the top to latest in time at the bottom. Generally, only a subset of records is shown in the listing at any time, based on settings in the filter tab of the disassembly control panel, the global mnemonic view state, and the individual mnemonic view state for packets.[7]

Please note there is a distinction between data records acquired by the hardware and disassembly records displayed in the listing grid. For LP data records, there is a one-to-one correspondence between data records and disassembly records. For HS data records, the correspondence varies depending on what part of the HS burst is being displayed. Generally, one disassembly record is used to display one packet byte (for one lane) or one one non-packet byte (for all active lanes). For the remainder of this document, unless it is clear from context, the term "record" will refer to a disassembly record.

Columns in the grid represent data fields associated with records, whether direct content acquired from the DPhy bus, derived data from that content, or other attributes created by the application. Not all fields apply to all record types, in which case a field will generally contains dashes.

The listing grid contains vertical and horizontal scroll bars for scrolling visible rows and columns in the grid. Other mechanisms are available for scrolling or selecting viewable rows in the listing including: key strokes, clicking in the cursor panel, selecting among several context menu options, and buttons in the search and video tabs of the disassembly control panel.

4.3.2.1 Column and Row Manipulation

The user has control over what columns are displayed, how they are ordered, and how field data are formatted in the column grid. Columns consist of a header in the first row, a radix selection in the second row, followed by field data starting with the third row. The following sections outline field- or column-related functions.

4.3.2.1.1 Selecting Columns

Similarly, single columns can be selected by right-clicking on the column header (i.e. the field name of a column). A contiguous region of columns can be selected by first selecting a column then selecting a second column while holding the shift key down. In addition, a discontinuous set of columns can be selected by clicking while holding the control key down. When a set of columns is selected, certain options in the column context menu will apply to each column, e.g. "Delete Columns", "Restore Select Column Width(s)"

4.3.2.1.2 Selecting Rows

Single rows can be selected by right-clicking on the row header (i.e. the Sample field of a record). A contiguous region of rows can be selected by first selecting a row then selecting a second (later) row while holding the shift key down. Once selected, rows can by copied to the clipboard with Ctrl-C or the "Copy Selected Rows" menu option in the

[7] These concepts are described further later in this section.

Edit menu. The total time occupied by the selected rows is shown in the Cursor Status Display at the top of the disassembly window associated with the field text "Sel:".

4.3.2.1.3 Measuring Time Between Events

There are two methods to measure time between two events in the disassembly. The first is to use cursors as follows:

1. Right-click on a cell in the row associated with the first event and select "Move Cursor1 Here"
2. Right-click on a cell in the row associated with the second event and select "Move Cursor2 Here"
3. The time between events is displayed in the "Delta" field of the Cursor Status Display at the top of the disassembly window.

The second method uses row selection as follows:

1. Left-click on the Sample cell in the row associated with the first event
2. Left-click on the Sample cell in the row associated with the second event while holding down the Shift key
3. The time between events is displayed in the "Sel" field of the Cursor Status Display at the top of the disassembly window.

4.3.2.1.4 Add Column(s)

To add a column field in the listing grid, right-click on a column header and select the "Add Column(s)" menu option to bring up the Add Column dialog. Check the desired column fields to display and click OK.

4.3.2.1.5 Remove Column(s)

To remove a column field in the listing grid, select one or more columns and press the Delete key. Alternatively, right-click in one of the selected column headers and choose "Delete Column(s)". If multiple columns are to be deleted, the user is asked for confirmation.

4.3.2.1.6 Reordering Columns

To change the display order of a visible column, right-click and drag the column header to a new position. Also, you can also first select a group of columns and then right-click and drag them. Discontinuous groups that are moved aremade contiguous after dragging.

4.3.2.1.7 Setting Column Widths

Column widths are automatically set to accommodate the widest string or value to be displayed and are updated whenever the field radix is changed. However, the user may adjust column width by selecting the right edge of a column header and dragging it. A column's width may be restored to its default using the column context menu option "Restore Selected Column Width(s)" or simply double-clicking on the column header.

4.3.2.1.8 Setting the Field Radix

Most fields are numeric and have an underlying value associated with it (Boolean fields are also numeric and are associated with a 0 or 1 value). Numeric fields can be displayed as binary, decimal, or hexadecimal by right-clicking the radix context menu of a

particular column sub-header (second row in grid). In addition, some fields have a default symbolic association -- basically a built-in number-to-string mapping -- that may be available in the menu. Finally, a user can define a custom symbol file to use for number-to-string translation (see section 4.3.2.1.10).

4.3.2.1.9 Setting the Time Field Reference

The time field displays the time-stamp of a record, indicating when the data was acquired relative to the start of trace capture (see section 4.3.2.2.4). DPhyDecoderHSCtl supports viewing time-stamps relative to a global time reference selected by the user via the radix context menu associated with the time field. Records occurring before the global time reference have a negative time field value and records occurring afterwards have a positive time field value.

The following time field display options are provided in the Time radix context menu:

- Relative to Start – display time-stamps relative to the first record.
- Relative to Trigger – display time-stamps relative to the trigger record
- Relative to Cursor1 – display time-stamps relative to cursor1
- Relative to Cursor2 – display time-stamps relative to cursor2
- Relative to Previous – display time-stamps relative to the preceding *visible* record

4.3.2.1.10 Defining and Using a Symbol File

To associate a radix file to a numeric field, select the "<New Symbolic File>" option in the radix context menu. This brings up an open file dialog to browse for and select the new symbol file. Once the symbol file has been selected, the context menu will enable the "Symbolic (File)" option (and it will be checked).

Symbol files are text files containing number-to-string mappings, where each mapping consists of a Boolean predicate equation and a string. During disassembly, the equation from each mapping is evaluated in order for each field value and the string from the first mapping whose equation evaluates true is displayed.

Predicate equations consist of one or more terms, one term per line. In multi-term equations, all but the last term in the equation are followed by "AND" or "OR" forming a Boolean equation from the terms. Finally, the last term of a predicate equation is followed by a colon, and then the symbolic string to associate with the equation enclosed in quotes.

Each predicate term consists of a relational operator and a value. Relational operators are ">", "<", ">=", "<=", "==", and "!=". Values are interpreted as decimal unless an 'h' or a 'b' is appended to denote hexadecimal or binary respectively. In addition, for hex or binary values, the character 'x' may be used as a "don't care" digit (if the first character is an 'x' it represents don't care digits up to the width of the field)

For example, the following lines define a predicate equation to detect values between 0x10 and 0x40 or if a value is odd:

// predicate equation
> 10h AND
< 40h OR
== x1b : "Range between (10h, 40h) or odd"

For values in the disassembly where this equation evaluates true, the string "Range between (10h, 40h) or odd" will be displayed.

Some notes about symbol file usage:

- Note that blank lines and lines that begin with "//" (which can be used for comments) are ignored by the parser.
- Predicate terms are interpreted as a sum-of-products equation and so AND has higher precedence than OR. Thus, predicates that describe the equation "a AND b OR c AND d" is parsed "(a AND b) OR (c AND d)".
- White space is **required** between the relational operator, the value, the "AND", "OR" and ":" delimiters, and the string.
- Mappings are evaluated in order, so subsequent predicate equations do not need to exclude values that would have already satisfied prior mappings.
- If not mapping qualifies for a value, a string with "?" is displayed. To avoid this, a default mapping can be appended to the end of the symbol file with the catch-all predicate ">= 0".

4.3.2.2 Field Descriptions

4.3.2.2.1 Mnem Field

The mnemonic field is a symbolic-only field that conveys the record type. The string displayed in this field can be customized to tabulate and show certain other fields in the record and their values. This behavior is configured using the "Mnem Cfg…" button on the Options tab of the disassembly control panel. Using this feature is simply another way to view fields in a record, using the mnemonic column to display the field rather than using a separate column in the listing.

4.3.2.2.2 Sample Field

The Sample field represents a record's ordinal number in the listing (i.e. essentially the disassembly record number). Gaps in the sample number generally indicate that there are records not displayed in the current view, though there are some sample numbers that are never displayed (the values are used internally but not meant for display).

4.3.2.2.3 Disp Field

The Disp field is a column used for showing the mnemonic view state of packet headers. A "packet" from a disassembly point-of-view includes not only protocol packets but escape packets and other data groupings such as a skew calibration, burst error data, and burst data in when sync detection is disabled (called HS Raw packets). A "packet header" from a disassembly point-of-view is the first record in the disassembly associated with a packet.

This "Disp" field is blank for non-packet byte records but contains one of three indicators for a record containing a packet header: "+", "++", or "-". These indicators correspond to

a mnemonic view state of "closed", "mnem-fields", "mnem- and packet-fields" respectively. When clicked, the mnemonic view state of the packet cycles to the next state (see section 4.3.2.5).

Note: the mnemonic view state of *all* packets can be forced by clicking in the second row of the Disp column, which is usually the Radix row but for the Disp column contains "+", "++" and "-" indicators that can be clicked to cycle the global mnemonic view state.

4.3.2.2.4 Time Field

The Time field represents displays a record's time-stamp, which the user may choose to display relative to a number of time references (e.g. start of trace, cursor or trigger position, etc.) Please see section 4.3.2.1.9 for more information.

By default, the time-stamp is displayed with a radix of Symbolic (Default), which displays the time as a string, e.g. "1.300 ns", but alternatively it may be displayed as a numeric value (hex or decimal), which converts time to an integer number of picoseconds. This allows the time field to be used in search and filter criteria, for example, in restricting record display or search to a limited time range.[8]

4.3.2.2.5 Param Fields

In the MIPI CSI-2 and DSI, many packet types are associated with one, two or three named parameter fields (as opposed to larger blocks of generic data such as pixel data, blanking bytes, LUT tables, etc.). The disassembly window organizes these packet parameters into the fields: "Param1", "Param2" and "Param3".

For example, the Generic Short Write packet can have 0, 1, or 2 parameters. For zero-parameter writes, all Param fields will have dashes displayed in them. For one-parameter writes, "Param1" will display the value of the single-byte parameter. And for two-parameter writes, "Param1" and "Param2" will display the single-byte parameters.

Another example is the DCS Set Column Address command that has two 16-bit parameters. In this case, "Param1" and "Param2" will display the 16-bit StartColumn and EndColumn parameters respectively.

Finally, note that when the Param fields are added as mnemonic fields using the "Mnem Cfg…" button, the actual parameter names are displayed in the mnemonic. For this reason, in general, the user may find it convenient to have the Param fields selected as fields to display in the mnemonic.

4.3.2.2.6 LPSeq Field

The LPSeq field indicates the LP sequence state of the DPhy Decoder at the time the record was recorded. The LP sequence state represents a position in decoding DPhy LP signaling, for example, the state LP-320 records having seen the sequence LP11, LP10,

[8] Currently, searching or filtering on the time-stamp field when in symbolic mode may not behave as expected, as comparisons are made alpha-numerically in this radix.

LP00 (the first three signaling states of a BTA). The following LP sequence states are used:[9]

State	LP Seq
LP-Unk	Non-LP11, invalid or unknown sequence state
Stop	LP11
LP-Rqst	LP11, LP10
LP-320	LP11, LP10, LP00
LP-3202	LP11, LP10, LP00, LP10
BTA	LP11, LP10, LP00, LP10, LP00
BTA-Exit	LP11, LP10, LP00, LP10, LP00, LP10
LP-3201	LP11, LP10, LP00, LP01
LP-Esc	LP11, LP10, LP00, LP01, LP00
LP-Esc-Exit	LP11, LP10, LP00, LP01, LP00, LP10
HS-Rqst	LP11, LP01
HS-Prepare	LP11, LP01, LP00
HS	In HS burst

4.3.2.2.7 PktLen Field

The PktLen field applies to records that show the first byte of a packet and indicates the total number of bytes associated with the packet (including header and CRC fields).

4.3.2.2.8 VC Field

The VC field applies to records that show the first byte of a packet and displays the 2-bit virtual channel field of the packet. **Error! Bookmark not defined.**

4.3.2.2.9 DataType Field

The DataType field applies to records that contain the first byte of a packet and displays the 6-bit data type field of the packet. **Error! Bookmark not defined.**

4.3.2.2.10 DCSCmd Field

The DCSCmd field applies to records that contain the first packet byte of a DCS read request short write, or long write and displays the 8-bit DCSCmd field.

4.3.2.2.11 LP Fields

There are five LP fields: "LP0", "LP1", LP2", "LP3" and "LPClk". These fields are present in all record types and reflect the LP lane state of lanes 0-3 and Clk respectively. Note that unused lanes (i.e. those exceeding than the maximum lane count setting - 1) always show the LP11 state, even if the lane input is disconnected. A default SymDef mapping is provided to map field values of 0-3 to LP00, LP01, LP10, and LP11 respectively. .

4.3.2.2.12 Data Fields

There are four Data fields: "Data0", "Data1", "Data2", "Data3". These fields show the data byte value per lane associated with the record. HS records will display bytes in the Data fields associated with active lanes. They will also show data bytes associated with

[9] Note that the DPhy Decoder does not distinguish between the LP00 state called HSPrepare and the HS-0 state called HSZero. The sequence state for this period is called HS-Go.

HS-Zero, HS-Sync and HS-Trail states (fractional bytes are not displayed). On the other hand, only Data0 may show LP data bytes, including LPDT packet bytes, as well as escape and trigger byte codes associated with the escape signaling protocol.

4.3.2.2.13 Trig Field

The Trig field applies to all record types and is a Boolean value (0 or 1) that represents the result of trigger criteria evaluation for the record. There is no limit to how many records may have their Trig field set. Moreover, non-zero prefill settings may mean the record associated with the hardware trigger event is not the first record with Trig == 1 in the trace. If it is important, use the Cursor Panel or context menu to go to the record associated with the hardware trigger record (i.e. the record triggering acquisition). A default SymDef mapping is provided to map field values of 0 to "---" and 1 to "Trig".

4.3.2.2.14 Frame Field

The Frame field applies to records that contain the first packet byte of all video-related packet types, including CSI Frame Start, Frame End, Line Start, Line End; DSI VSync Start and VSync End; blanking and video packets. Starting at one, it reflects an ordinal frame number associated with the packet. It also corresponds with frames listed in the video tab of the Disassembly Control panel. Generally, the frame number will increment with each Frame Start or VSync Start packet, but might otherwise increment if a video packet occurs with a new VC or DataType.

4.3.2.2.15 ActLine Field

The ActLine field applies to records that contain the first packet byte of an active video packet, *where a preceding Frame Start or VSync Start packet has already been seen* (otherwise, the line number is unknown). Starting at one, it reflects the active line number of the packet in the frame.

4.3.2.2.16 Lane Field

The Lane field applies to all records and indicates the corresponding data lane of its data byte. For LP records, Lane field is always zero. For HS records, the Lane field can be 0 through the maximum lane count minus 1.

4.3.2.2.17 ECC Fields

There are three ECC fields: "ECC", "ExpECC", and "ECCOk", displaying the ECC byte contained in a packet header, the expected (computed) ECC bytes associated with the header, and a comparison result of the two respectively. These fields apply to records that contain the first packet byte. ECCOk has a default SymDef mapping for the boolean comparison of 0 == "Err" and 1 == "Ok".

4.3.2.2.18 BusOwn Field

The BusOwn field applies to all DSI records and indicates which end of the bidirectional link is transmitting (i.e. owns the bus). A default SymDef mapping for the Boolean value is 0 == "Dev" and 1 == "Host".

4.3.2.2.19 BurstErr Field

The BurstErr field displays whether or not a packet is a burst error packet. A default SymDef mapping for the Boolean value is 0 == "---" and 1 == "Err".

4.3.2.3 Trigger and Cursors

The hardware trigger record and two cursor records can be displayed in the listing grid, changing the background highlighting of their associated records. The trigger record indicates the location of the hardware trigger for capture and is a static fixed position that cannot be changed but can be used as a reference for time measurement and Goto operations. Its Trig field will be set to 1, though it may not be the only record with Trig == 1, nor is it necessarily the first occurrence of a record with Trig == 1, depending on the Prefill percentage setting.

Cursors are enabled by checking the associated checkbox in the top of the cursor panel to the right of the listing grid and can be controlled from the cursor panel control (see Cursor Panel section for more details). The current cursor positions and the delta time between them are displayed above the listing grid, using the current global time reference set in the time field radix context menu.

Cursor related functions are also available in the column context menu available by right-clicking in any grid cell (except the radix sub-header row). In particular, the user can select "Goto Cursor1" or "Goto Cursor2" to scroll the listing grid to the record location of the indicated cursor. Also, if the context menu is brought up from a non-header cell, the "Move Cursor1 Here" and "Move Cursor2 Here" options are also available.

4.3.2.4 Disassembly View Content

A main feature of the disassembly window is to allow the user to set criteria for filtering records, only displaying a subset of acquired records from the disassembly view. This is done through several mechanisms: enabling/disabling LS/HS signaling, adjusting the global mnemonic view or the mnemonic view of individual packets, and setting packet and record filter criteria. Each mechanism successively restricts records shown in the disassembly.

A main option for controlling the disassembly view content is the "Show LP/HS Signaling" check-box on the Options tab of the Disassembly Control Panel. Disassembly is affected by the check-box state as follows:

- **Checked**: shows all record types, including non-packet traffic such as LP records, and HS signaling record types such as. HS-Zero, HS-Sync, and HS-Trail.
- **Unchecked**: hides all record types except for packet records, which include HS, LPDT, escape, burst error, HS raw, and skew calibration packets.

When the option is changed, the listing is updated to display records only applicable to the new criteria. In the case of packet records, the mnemonic view state determines whether only the first packet byte is shown or all packet bytes are shown (see next section).

4.3.2.5 Mnemonic View State

Mnemonic view state is an attribute of packets that affects how the packet is displayed in the disassembly listing. Its setting determines whether only the first byte of a packet is

displayed, or all bytes of the packet are displayed, and whether the user-specified mnemonic fields associated with the packet are displayed.

There are three mnemonic view states:

Closed	Only the first packet byte is displayed.
Mnem-Fields	Only the first packet byte plus its mnemonic fields are displayed. Mnemonic fields are fields selected by the user to be displayed with the mnemonic via "Mnem Cfg…" button).
Mnem-and Packet-Fields	All packet bytes are displayed. Mnemonic fields are also shown for the first packet byte.

The mnemonic view state of a packet is shown in the Disp field in the record using the indicators "+", "++", or "-" (corresponding to the states in order in the table above). To cycle an individual packet's mnemonic view state, click on the indicator in the Disp column. To cycle all packet mnemonic view states at once, click the indicator in the second row of the Disp Column (i.e. Radix row).

4.3.2.6 Column Context Menu

The column context menu is brought up by right-clicking in any cell except for the radix row (second row) of the listing grid. Depending on the cell location clicked to bring up the menu, certain options will be enabled or disabled. Here is a summary of all the functions in the column context menu:

Function	Description	Shortcut
Add Column(s)	Brings up dialog to add columns (i.e. make fields visible) to the listing grid.	
Delete Column(s)	Deletes selected columns.	
Restore Selected Column Width(s)	Restores selected columns to their default width.	
Select All	Selects all records in the disassembly	Ctl-A
Goto Cursor1	Scrolls the listing grid to the cursor1 record.	Ctl-1
Goto Cursor2	Scrolls the listing grid to the cursor2 record.	Ctl-2
Goto Trigger	Scrolls the listing grid to the hardware trigger record.	Ctl-T
Goto…	Brings up a dialog to enter a sample number to scroll the listing grid to (the nearest visible record is used).	Ctl-G
Move Cursor1 Here	Moves the cursor1 position to the current record.	
Move Cursor2 Here	Moves the cursro2 position to the current record.	
Search Frame Start	Fills in the search criteria to search for Frame	Ctl-Alt-F

	Start for CSI or VSync Start for DSI. Then, the Next Search function is performed. .	
Search Same Mnem	Fills in the search criteria to search for records that match the mnemonic value associated with the current record. Then, the Next Search function is performed. Note that the current cell can be any field type.	Ctl-Alt-M
Search Same Val	Fills in the search criteria to search for records that match the current cell's field value. Then, the Next Search function is performed.	Ctl-Alt-V
Search Same Mnem And Val	Fills in the search criteria to search for records that match the mnemonic value associated with the current record and the current cell's field value. Then, the Next Search function is performed.	Ctl-Alt-B
Next Search	Scrolls to the next record satisfying the search criteria	Ctl-S
Next Packet	Scrolls to the next packet start.	Ctl-P
Next Frame Start	Scrolls to the next CSI Frame Start or DSI VSync Start packet.	Ctl-F
Next Same Mnem	Scrolls to the next record that matches the mnemonic value associated with the current record.	Ctl-M
Next Same Val	Scrolls to the next record that matches the current cell's field value.	Ctl-V
Next Same Mnem And Val	Scrolls to the next record that matches the mnemonic value associated witht the current record and the current cell's field value.	Ctl-B
Prev Search	Scrolls to the previous record satisfying the search criteria	Alt-S
Prev Packet	Scrolls to the previous packet start.	Alt-P
Prev Frame Start	Scrolls to the previous CSI Frame Start or DSI VSync Start packet.	Alt-F
Prev Same Mnem	Scrolls to the previous record that matches the mnemonic value associated with the current record.	Alt-M
Prev Same Val	Scrolls to the previous record that matches the current cell's field value.	Alt-V
Prev Same Mnem And Val	Scrolls to the previous record that matches the mnemonic value associated witht the current record and the current cell's field value.	Alt-B
Exclude All But Frame Start	Sets and applies the filter criteria to filter all records except for CSI Frame Start of DSI VSync Start packets.	Ctl-X, F
Exclude All But Same Mnem	Sets and applies the filter criteria to filter all records except those that match the mnemonic	Ctl-X, M

	value associated with the current record.	
Exclude All But Same Val	Sets and applies the filter criteria to filter all records except those that match the current cell's field value.	Ctl-X, V
Exclude All But Same Mnem and Val	Sets and applies the filter criteria to filter all records except those that match the mnemonic value associated with the current record and the current cell's field value.	Ctl-X, B
Modify Filter From Current Cell	Contains a sub-menu with three items: ▪ Replace Filter Term ▪ Add OR Filter Term ▪ Add AND Filter Term Selecting one of these menu items will perform the requested function based on the current cell's field name and value. The operator used is "==".	
Modify Search From Current Cell	Contains a sub-menu with three items: ▪ Replace Search Term ▪ Add OR SearchTerm ▪ Add AND Search Term Selecting one of these menu items will perform the requested function based on the current cell's field name and value. The operator used is "==".	

4.3.2.7 Radix Context Menu Summary

The radix context menu is brought up by right-clicking in the sub-header row (second row) of the listing grid and is used to set the display format of the current column. The functions in the menu have been described in earlier sections. Here is a summary of all the functions in the radix context menu (except for the context menu for the Time field):

- **Hexadecimal** – sets the radix to hexadecimal (enabled for numeric fields)
- **Decimal** – sets the radix to decimal (enabled for numeric fields)
- **Binary** – sets the radix to binary (enabled for numeric fields)
- **Symbolic (Default)** – sets the radix to symbolic using the default translation internal to the application.
- **Symbolic (File)** – sets the radix to symbolic using the translation defined by the symbolic file specified by the user using the "<New Symbolic File>" menu option.
- **<New Symbolic File>** – brings up an open file dialog to select a symbol file to associate with the current column.

In addition, the time field radix context menu has several more options to set the desired time field reference, which determines how the time field is displayed. One of these options is always checked:

- **Relative to Start** – sets the global time field reference to the first acquired record
- **Relative to Previous** – sets the time field reference for each record to the previous displayed record (i.e. displays delta time between records)
- **Relative to Trigger** – sets the global time field reference to the trigger record
- **Relative to Cursor1** – sets the global time field reference to the cursor1 record
- **Relative to Cursor2** – sets the global time field reference to the cursor2 record

4.3.3 Cursor Control Panel

The cursor control panel (cursor panel, for short) is a custom control with three narrow columns on the right side of the listing grid. Each narrow column is similar to a vertical scroll bar, each associated with either a cursor or the trigger (for the purposes of this description, the trigger can be thought of as a special cursor with fixed position). Cursors represent a specific record position in the listing, similar to a scroll bar, where the top of the panel represents the start of the listing and the bottom of the panel represents the end of the listing.

The first column in the cursor panel represents the trigger and, if enabled, is drawn as a red square labeled with a 'T'. The trigger cursor is always enabled. The second and third columns represent cursor1 and cursor2 respectively and, if enabled, are drawn as a blue square labeled with a '1' or a blue square labeled with a '2'. A check box above each cursor column can be used to enable or disable each cursor. Disabled cursors are drawn with a gray background in the cursor panel and are not visible in the disassembly listing.

Like a scroll-bar, the cursor panel is meant to represent the entire vertical span of the listing windows. Cursor positions within the panel symbolically indicate where each lies within the listing, i.e. a cursor toward the top of the panel indicates a record position near the start of the listing and a cursor toward the bottom of the panel indicates a record position near the end of the listing. The times associated with cursor1 and cursor2 positions and the difference between them are displayed in readouts above the listing grid.

In addition to the cursor symbols, a horizontal white region is drawn across the cursor panel. This region represents the currently viewed region of the listing, having a position and thickness corresponding to the current viewed region relative to the total listing.

Finally, horizontal orange lines are drawn to indicate the occurrence of at least one search result in the associated region of the disassembly listing. If the search record density is high enough, this can have the effect of shading the background of entire regions of the cursor panel orange.

The cursor panel supports the following operations for setting cursor positions and scrolling the listing:

- Left-clicking and dragging a cursor square moves the cursor position. While dragging, the current cursor position (Sample #) is displayed in a pop-up box.

- If the Shift key is pressed and held while dragging, the listing will scroll with the cursor position, otherwise the listing will not scroll.
- If the Control key is pressed and held while dragging, the cursor will scroll more slowly, allowing for finer control.
- Double clicking a cursor in the panel scrolls the listing window to the cursor position.
- Double-clicking in the cursor panel (not on a cursor) scrolls the listing window to the position clicked.

4.3.4 Diassembly Control Panel

The Diassembly Control Panel is located at the bottom part of the disassembly window and has six tabs: Options, Filter, Search, Video, Packets, and <Minimize>. The functions and controls provided by each tab are described in the following sections.

4.3.4.1 Options Tab Page

The Options tab contains controls for configuring acquisition, decoding, and disassembly display.

4.3.4.1.1 Acquisition Options

There are three user-controls for acquisition. They are described below:

- **Prefill Pct** – up/down control that sets the trigger position relative to the acquisition. The value is an integer percentage of the acquisition memory buffer size and ranges from 5% to 95%. Setting the Prefill Pct value to minimum will cause the trigger record to appear near the beginning of the trace. Setting to 50% places the trigger record to appear in the middle of the trace. Etc.

  Because disassembly first requires seeing an LP11 state before decoding, the minimum prefill percentage is set to 5%. Except in extreme cases, this should allow enough time preceding a trigger record at the end of an HS burst to include an LP record containing LP11 for proper disassembly.
- **Memory Depth** – drop-down-box that provides options for setting the size of the acquisition buffer. The size ranges from 1 MB to 1024 MB. As expected, smaller buffer sizes correspond to faster acquisition, upload, decoding, and display. In addition, filter and search functions are faster with smaller traces
- **Allow Trigger Before Prefill** – check box that determines whether an acquisition is allowed to trigger before the prefill requirement is met. This option is necessary for unique triggers that occur early on in a test. If unchecked, while a trigger event under these conditions might be seen in the real-time statistics, acquisition may not occur.

4.3.4.1.2 Disassembly Options

Disassembly controls are provided for configuring trace decoding and disassembly display (see Figure 5).

General options, unrelated to protocol are:

- **Grid Font Size** – up/down control that increases or decreases the font size of the grid display. Values can range from 6 to 12.

- **Highlight Filter Gaps** – check box that sets whether or not filtered records cause a double-thick horizontal grid-line to be displayed between visible rows.
- **Disable Disassembly** – check box that disables disassembly after acquisition and upload. The main use of this option is for debugging, allowing a trace to be acquired that causes a catastrophic error in decoding, saved, and sent to the Moving Pixel Company for analysis.
- **Reanalyze** – button that restarts decoding and disassembly on the current trace data. This may be needed if initial decoding was aborted before decoding was complete (in which case, only a partial disassembly is displayed). Click on the Reanalyze button to restart and complete a full decoding.
- **(Disable Sync Detect)** – this check box is not on the Option tab but rather in the main application window because it affects real-time processing as well as disassembly. When checked, HS Sync bytes are not recognized by the instrument and thus no HS protocol packets are decoded in the disassembly. Instead, entire HS bursts are labeled as "HS Raw" packets and unaligned lane data is presented as payload. This is useful for viewing low-level phy traffic during debugging.

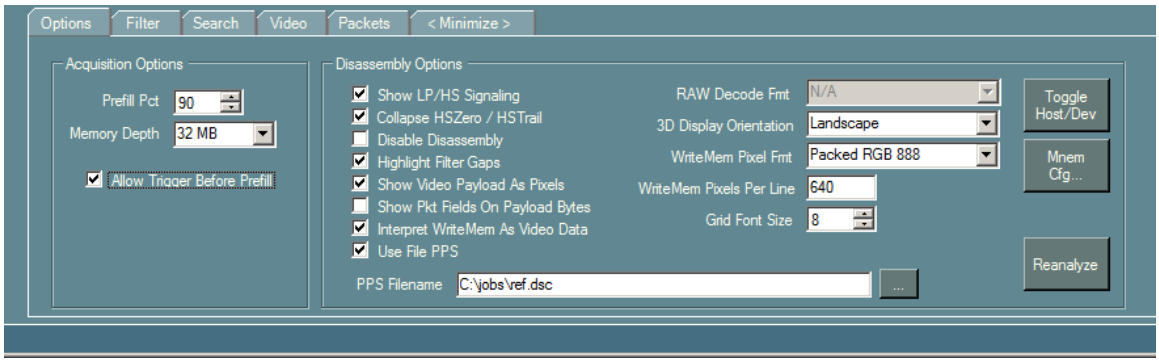

Figure 5 – Disassembly Options

The remaining controls in the Options window are protocol-related options. They are:

- **Toggle Host/Dev** (DSI) – button that toggles the bus ownership flag (i.e. Host or Device) for the first record in the acquired trace. This will rarely be necessary, and only if acquisition was made when the instrument has incorrect bus ownership state (which should only happen when invalid bus activity confused the instrument or in other atypical cases). Clicking this button will affect how the entire acquisition is disassembled as DataType values in DSI represent different packet types for the host versus a peripheral.
- **Mnem Cfg…** (CSI & DSI) – button that brings up the Mnemonic Configuration dialog, allowing the user to select fields to display with the mnemonic in the listing when its mnemonic view setting allows.
- **Show LP/HS Signaling** (CSI & DSI) – check-box that selects whether low-level LP and HS signaling records are displayed. When enabled, the disassembly shows all LP records and HS records including HS-Zero, HS-Sync, and HS-Trail.

- **Collapse HSZero / HSTrail** (CSI & DSI) – check-box that configures how HS-Zero and HS-Trail records are displayed. When unchecked, each HS-Zero or HS-Trail record represents one HS byte in an HS burst. In this case, a typical HS burst will display many HS-Zero and HS-Trail records. On the other hand, when this option is checked, only one HS-Zero and HS-Trail is displayed per HS burst, representing the entire HS-Zero or HS-Trail segment. The time difference to the next record indicates how long the segment is.
- **Show Video Payload As Pixels** (CSI & DSI) **–** check box that configures how payload data for video packets is displayed in the disassembly. Without this option checked, each payload byte is displayed one-byte-per-record with no pixel decoding (just as all other non-video packets). However, with this option checked, pixels are decoded and presented, one pixel per record, with actual color components values displayed.[10]
- **Show Pkt Fields On Payload Bytes** (CSI & DSI) – check box that configures whether the values of packet-related fields are displayed for payload bytes in a packet. For example, fields such as PktLen, VC, DataType, Frame, ActLine, etc are all packet fields. Often it is useful to be able to see these fields when scrolling through disassembly of a long packet where the header byte has scrolled off the screen. On the other hand, when searching, usually the user doesn't want searches on these fields to hit on other than the first packet byte.[11]
- **Interpret WriteMem As Video Data** (DSI) – check box that indicates that WriteMemoryStart and WriteMemoryContinue commands should be interpreted as containing video data. WriteMemoryStart packets always start a new frame. The data format and line length are set by "WriteMem Pixel Fmt" and "WriteMem Pixels Per Line" respectively. Note that if this option is checked and both WriteMemory and Packed Pixel packets are present in the trace, only WriteMemory frame data will be catalogued in the Video tab.
- **RAW Decode Fmt** (CSI) **–** drop-down control that indicates the format to use for decoding RAW video packets.

Bayer GRBG	Decodes lines 1,3,5… as alternating green, red pixels and lines 2,4,6… as alternating blue, green pixels.
Bayer RGGB	Decodes lines 1,3,5… as alternating red, green pixels and lines 2,4,6… as alternating green, blue pixels.
Bayer BGGR	Decodes lines 1,3,5… as alternating blue, green pixels and lines 2,4,6… as alternating green, red pixels.
Bayer GBRG	Decodes lines 1,3,5… as alternating green, blue pixels and lines 2,4,6… as alternating red, green pixels.
Monochrome	Decodes raw pixels as luminence values.

[10] This discussion assumes that the mnemonic view of the video packet is "Mnem and Packet Fields". Otherwise, payload bytes are not visible.

[11] Note that checking the option "Search Only Pkt Hdrs" on the search tab has an equivalent effect, allowing only the first packet byte to qualify in searches.

- **3D Display Orientation** (DSI) – drop-down control that indicates the display orientation for viewing and saving 3D frames.
- **WriteMem Pixel Fmt** (DSI) **–** drop-down control that indicates the pixel format to use when decoding WriteMemory commands as video data. Options are:

Packed RGB 565	Packed RGB 121212
Packed RGB 666	Loose 20-bit YCbCr 422
Loose RGB 666	Packed 16-bit YCbCr 422
Packed RGB 888	Packed 24-bit YCbCr 422
Packed RGB 101010	Compressed DSC

- **WriteMem Pixels Per Line** (DSI) **–** text box that indicates the number of pixels per line when decoding WriteMemory commands as video data.
- **Use File PPS** (DSI) **–** check box that determines what PPS is used for decoding compressed video frames. If checked, the PPS Filename is used to extract a PPS to use for decoding. Otherwise, PPS data from the Picture Parameter Set command is used.
- **PPS Filename** (DSI) – text box that names a file to use for extracting a PPS structure to use for decoding compressed video frames (if Use File PPS is checked). If the file extension is ".dsc" then the DSC file is decoded to extract the PPS. Otherwise, the file is treated as a binary file and the first 128 bytes of the file are used as the PPS.

4.3.4.2 Filter Tab Page

The filter tab provides controls to filter or show records based on user criteria. Specifically, most controls in this tab help to define and apply a filter equation that is evaluated against each record to determine whether or not the record is displayed. Note that the application of the filter or show result is only against the records that remain visible as allowed by other options.

Some controls such as the Filter, Show, and Disable radio buttons update the disassembly listing as soon as they are used. On the other hand, changes in the Mnemonic Type list box and the Filter Term grid do not take effect until the Apply button is clicked.

Here is an overview of the controls contained in the filter tab:

- **Mnemonic Type List Box** – contains a list of all mnemonic types defined for the current view. The user checks packet-types and record-types to use as criteria for the overall filter equation.
- **Filter Term Grid** – defines predicate terms of the filter equation based on packet fields.
- **Set All Button** – checks all mnemonic types in the list box.
- **Clear All Button** – clears all selected mnemonic types in the list box.

- **Filter Radio Button** – enables record filtering and uses the filter equation to determine which records should not be displayed (i.e. if the filter equation evaluates true for a record, it is not displayed).
- **Show Radio Button** – enables record filtering and uses the filter equation to determine which records should be displayed (i.e. if the filter equation evaluates true for a record, it is displayed).
- **Disable Radio Button** – disables record filtering.
- **Clear Button** – clears all terms in the filter term grid.
- **Apply Button** – Applies any changes to the filter criteria, updating the disassembly listing.

The Mnemonic Type list box and the Filter Term grid together define the overall filter equation. The list box defines a set of mnemonic types that qualify records for further evaluation by the filter terms. That is, records that satisfy the filter equation must have at least one lane with a mnemonic type than is checked in the list box. So, for example, at the extremes, if no types are checked, the filter equation will evaluate false for all records. And if all types are checked, the filter equation for each record will evaluate solely to the result from the Filter Term grid.

The Filter Term grid defines zero or more Boolean terms (one per row) which compare a record field to a constant value. Terms are logically connected via AND or OR operations to build a Sum-Of-Products equation used in the overall filter equation. The AND operation takes precedence over the OR operation so A AND B OR C AND D is evaluated as (A AND B) OR (C AND D).

The filter grid defines four columns as follows:

- **Op** – defines how the term is logically connected to its predecessor, either via AND or OR (the first term, which has no predecessor is fixed to show IF). In addition to showing the logical operation associated with the term, this field is a drop-down control that provides options for adding or deleting terms. For AND terms, two options are available: add another AND term to the product or delete the current AND term. For IF or OR terms, two additional options are available: add another OR term to the equation or delete the current OR term (which includes all AND terms of the product).
- **Field** – drop-down control to select a record field name
- **Comp** – drop-down control to select a comparison operator (==, !=, <, <=, >, >=)
- **Value** – text box to enter a comparison value

To define a filter equation, begin with filling in the Field, Comp, and Value fields of the first term in the Filter Term grid. Next, select the Op drop-down and select "<Insert OR term>" or "<Insert AND term>" to add a new term to the equation. Fill in the fields of that term and continue inserting terms until the equation is fully defined.

Another method is to right-click in the disassembly grid and select one of the menu options that begin with "Exclude All But…". Alternatively, each of these menu options

has a keyboard shortcut sequence that begins with Ctl-X. For example, if you right-click on a cell in the PktLen field that has a value of 4 and select "Exclude All But Same Val", the filter list box will check all packet types and enter the term"IF PktLen == 00004" in the filter grid. Then, the Show radio button will be selected and then the disassembly will update.

Figure 6 shows the results of this operation for a video capture. In particular, filtering has eliminated all packets except for VSync Start. In addition, additional filter criteria limits records to those with the Frame between 4 and 15. Note that rows have a double-line dividing them. This is an optional highlighting method to indicate there are packets in the view that have been filtered. This highlight is enabled by checking "Highlight Filter Gaps" in the Options tab.

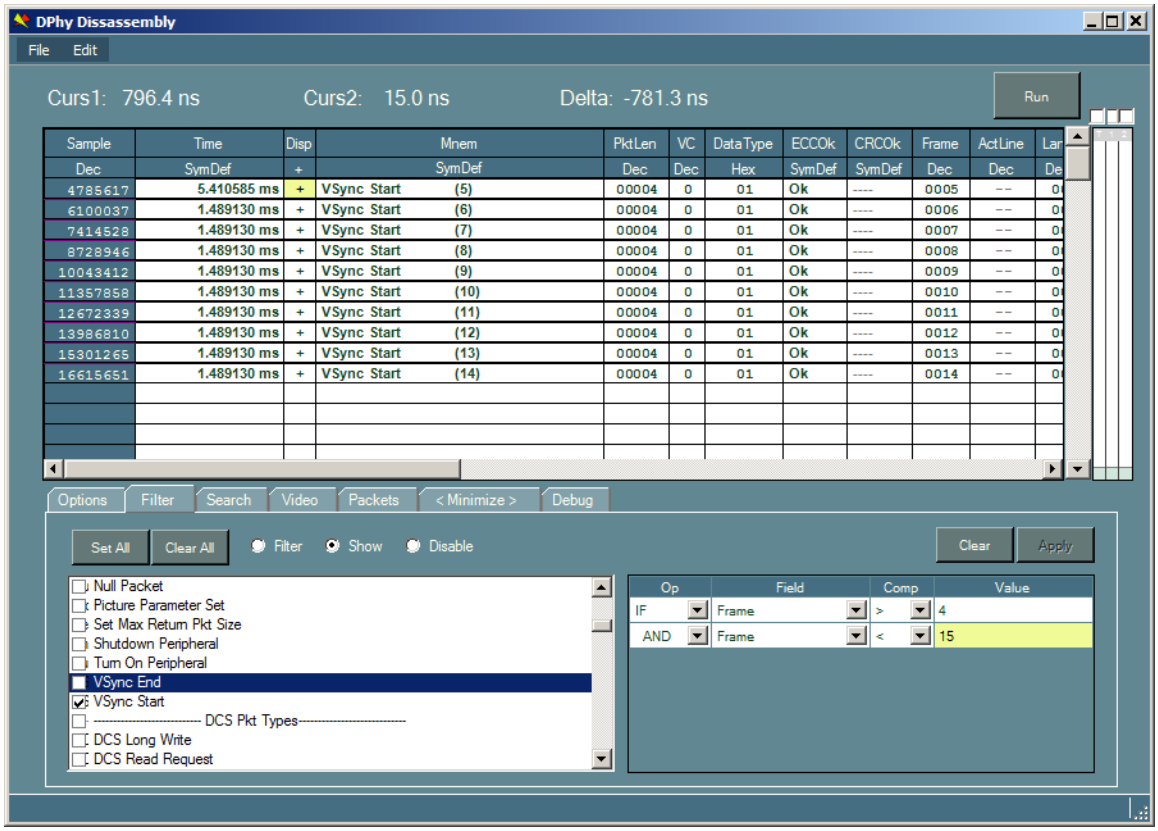

Figure 6 – Filter Example

Numeric field values are assumed to be in decimal unless appended with an 'h' for a hexadecimal value or a 'b' for a binary value. When using hex or binary values, an 'x' may be used as a "don't care" placeholder. Thus, the value "1xh" will match values from 10h to 1fh.

Symbolic field comparison symbolic is supported, but the user should understand that values are compared using string-comparison and so results may not be as intended. For example, if the user constrains the filter equation to select a time range when the Time field is set to symbolic, he might set up the following equation:

IF Time > 100 us AND Time < 200 us

However, the result of the string comparisons against Time values such as "120.888 ns" and "190.666666666 ms" will not be as desired. In general, the "==" and "!=" comparison operations are most predicatble, though be aware that comparisons are case-sensitive.

Note that changing the radix of a field from numeric to symbolic or symbolic to numeric *after defining filter or search terms* can affect the term's validity. Comparisons are performed on field values in the radix they are displayed (not the radix at the time the predicates were built). An error will occur if filtering or searching using a non-numeric predicate value on a field that is currently being displayed as a numeric value (though hex, decimal, and binary conversions are automatic).

4.3.4.3 Search Tab Page

The search tab contains controls for searching and optionally highlighting records that satisfy given criteria. Statistics about filtered and matched search records are also displayed.

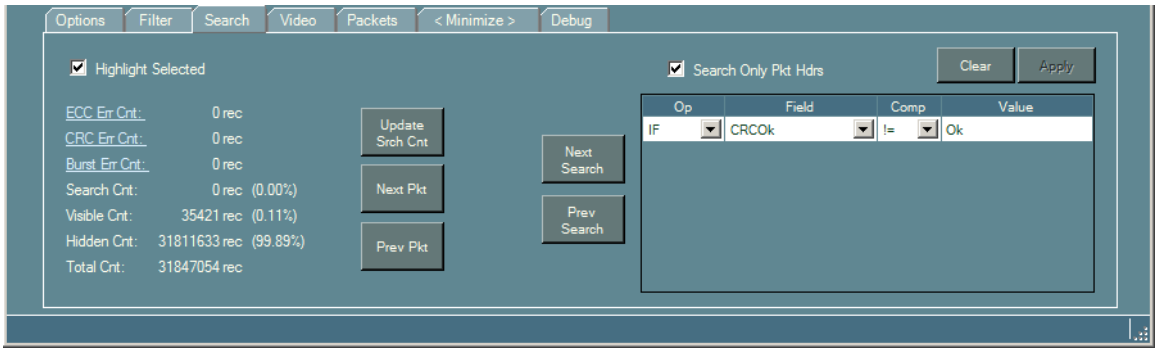

Figure 7 – Search Tab

Here is a description of the controls contained in the filter tab:

- **Highlight Selected –** when checked, records satisfying the search criteria are highlighted in the listing.
- **ECC Err Cnt –** displays the number of packets in the listing that have an ECC error. This label is clickable to auto-fill the Search Term Grid for highlighting and locating ECC error packets.
- **CRC Err Cnt –** displays the number of packets in the listing that have a CRC error. This label is clickable to auto-fill the Search Term Grid for highlighting and locating CRC error packets. In Figure 7 above, the search term for finding CRC errors has been auto-filled by clicking on the "CRC Err Cnt" label.
- **Burst Err Cnt –** displays the number of packets in the listing that have a burst error. This label is clickable to auto-fill the Search Term Grid for highlighting and locating burst error packets.

- **Search Cnt** – displays the number of records and percentage of all acquired records that satisfy the search criteria. Depending on the size of the trace, the current view, and the complexity of the filter and search equations, performing a count of all search records in the trace can be time consuming. An initial attempt to update the search count is made during disassembly update, but with a ½ second timeout. If the timeout occurs, the Search Cnt is displayed as "<update>", indicating the user needs to click on the Update Srch Cnt button if to recomputed.
- **Visible Cnt –** displays the number of records and percentage of all acquired records) that are currently visible in the listing.
- **Hidden Cnt –** displays the number of records and percentage of all acquired records that are currently hidden from view in the listing.
- **Total Cnt –** displays the number of acquired records.
- **Update Srch Cnt Button** – updates the Search Cnt readout if the initial attempt during disassembly update timed out (see Search Cnt Readout description).
- **Next Pkt Button** – scrolls to the next packet in the disassembly listing. Alternate ways of performing this function is to select "Next Packet" from the disassembly context menu or pressing Ctl-P.
- **Prev Pkt Button** – scrolls to the previous packet in the disassembly listing. Alternate ways of performing this function is to select "Prev Packet" from the disassembly context menu or pressing Alt-P.
- **Next Search Button**– scrolls the listing to the next record matching the search criteria. Alternate ways of performing this function is to select "Next Search" from the disassembly context menu or pressing Ctl-S.
- **Prev Search Button** – scrolls the listing to the previous record matching the search criteria. Alternate ways of invoking this function is the select "Prev Search" from the disassembly context menu or pressing Alt-S.
- **Search Term Grid** – allows the user to define predicate terms of the search equation. This grid operates identically to the Filter Term grid described in the previous section.
- **Search Only Pkt Hdrs** – when checked, restricts searches to only the first byte of a packet, which may improve search/update speed greatly (depending on other view settings). Generally, most user search criteria are intended for packet level search anyway.
- **Clear Button** – clears and filter term grid.
- **Apply Button** – Applies changes to the search term grid, updating the disassembly listing and readouts.

To search for and highlight records that satisfy a particular predicate equation, search criteria can be entered in to the search term grid identically to the filter term grid. The search equation is built from terms defined and applied to each record in the listing when the Apply button is clicked. If the Highlight Selected checkbox is checked, records that satisfy the search equation are highlighted in the listing (note that the search equation is only evaluated against unfiltered records). The "Next Search" and "Prev Search" buttons can be used to scroll the listing to the next and previous qualifying records respectively.

4.3.4.4 Video Tab Page

The Video tab of the Disassembly Control panel contains information about video frames decoded from the trace (see Figure 8)

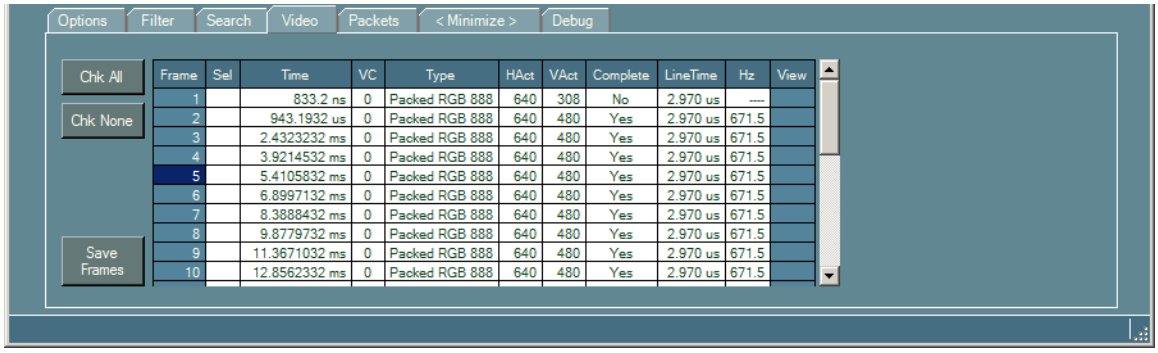
Options
Filter
Search
Video
Packets
< Minimize >
Debug
Chk All
Chk None
Save Frames
Frame Sel Time VC Type HAct VAct Complete LineTime Hz View
1 833.2 ns 0 Packed RGB 888 640 308 No 2.970 us ----
2 943.1932 us 0 Packed RGB 888 640 480 Yes 2.970 us 671.5
3 2.4323232 ms 0 Packed RGB 888 640 480 Yes 2.970 us 671.5
4 3.9214532 ms 0 Packed RGB 888 640 480 Yes 2.970 us 671.5
5 5.4105832 ms 0 Packed RGB 888 640 480 Yes 2.970 us 671.5
6 6.8997132 ms 0 Packed RGB 888 640 480 Yes 2.970 us 671.5
7 8.3888432 ms 0 Packed RGB 888 640 480 Yes 2.970 us 671.5
8 9.8779732 ms 0 Packed RGB 888 640 480 Yes 2.970 us 671.5
9 11.3671032 ms 0 Packed RGB 888 640 480 Yes 2.970 us 671.5
10 12.8562332 ms 0 Packed RGB 888 640 480 Yes 2.970 us 671.5

Figure 8 – Video Tab

In the video tab, a grid control displays one-line-per-decoded-frame having the following fields:

Frame	A frame number assigned to the frame
Sel	Click-area to select the frame for saving. An 'X' is alternately displayed and cleared with each click.
Time	Time stamp of first frame packet (generally Frame Start or VSync Start packet)
VC	Virtual channel
Type	Video format
HAct	Number of active pixels in a packet. If variable packet lengths were found, indicates the longest packet found.
VAct	Number of active lines
Complete	'Yes' is displayed if Frame Start and Frame End (CSI) or VSync Start and a second VSync Start (starting the next frame for DSI) was seen.
LineTime	The longest time period between active packets (CSI) or HSync/VSync Start packets (DSI).
Hz	The Frequency between Frame Start (CSI) or VSync Start (DSI) and the next Frame Start or VSync Start.
View	Click-area labeled "View" to bring up a window displaying the video frame.

4.3.4.4.1 Scrolling Disassembly to Frame Start

To scroll disassembly to the location of the first packet in the video frame, click on the frame number in the video grid. The first packet of a video frame is usually the Frame Start or VSync Start packet, but if these packets are missing, they could be other video packet types.

4.3.4.4.2 Viewing Video Frames

To view a video frame, click on the "View" cell associated with the frame in the video grid (see Figure 9). This brings up the Frame Display dialog showing the captured frame, with a title that indicates the frame number being displayed and its dimensions.

The user can resize the dialog manually using the mouse by grabbing a dialog edge and dragging. If the image becomes too large for the dialog size, scroll bars appear to pan the image into view.

The Frame Display dialog has the following controls:

- **Next / Prev** – buttons to single-step forward or backward in the frame sequence, allowing each frame to be viewed in turn.
- **Play** – button to play and loop the frame sequence (at a slow rendering rate not in real-time).
- **Frame Slider --** unlabeled slide control representing the frame sequence with the current slide position indicating the current frame. Dragging the slide control selects the current frame.
- **Resize –** button to force resizing the dialog to fit the acquired frame

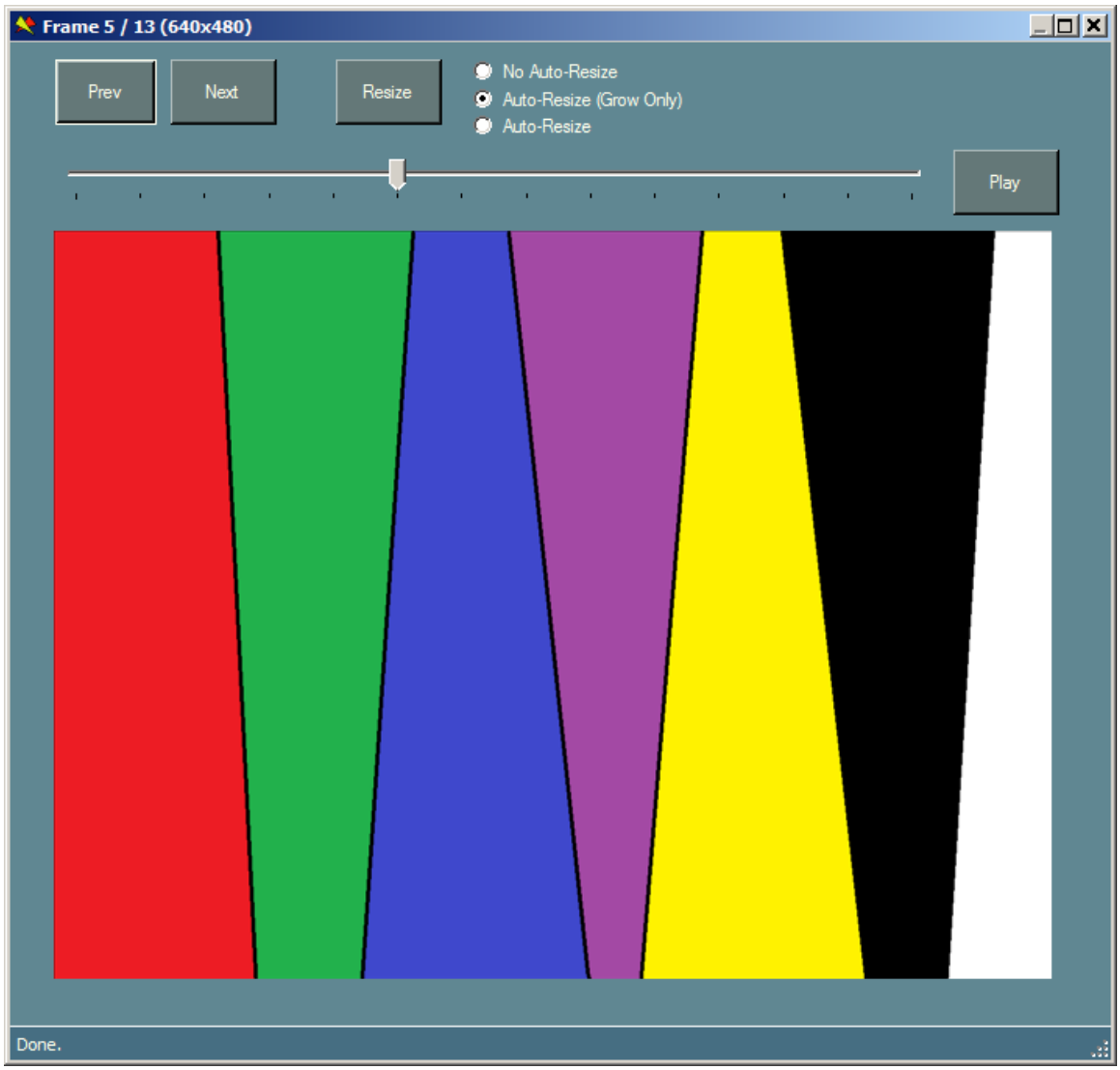

Figure 9 – Frame Display Dialog

In addition, the dialog has option buttons to select one of the following resize modes:

- No Auto-Resize
- Auto-Resize (Grow Only)
- Auto-Resize

These options determine when the dialog is automatically resized to fit the image. Note that the image itself is not resized, just the dialog. Selecting "No Auto-Resize" means that the dialog is never automatically resized to fit the image. Whereas, "Auto-Resize (Grow Only)" causes the dialog to auto-resize if it is too small to display the image (but not too large) and "Auto-Resize" allows the dialog to always adjust to the image it displays.

4.3.4.4.3 Saving Video Frames

To save video frames to files, click on the cell labeled "View" for each frame you want to save, causing an 'X' to be displayed indicating that the frame is selected to be saved. Clicking on an 'X' unselects the frame. Alternatively, clicking on the "Chk All" button selects all frames and clicking on the "Chk None" button clears all frame selections.

Once frames have been selected, clicking the "Save Frames" button brings up a save dialog to browse and enter a file name.

The extension used for the file name indicates the format to use for saving the frame data. If the extension is "BMP", "JPG", "GIF", ".PNG", ".TIFF" (case is irrelevant), the file is saved in the requested format. Otherwise, the file is saved in binary format, exactly as received from the MIPI bus.

In saving a single frame, the file name is used unchanged. In saving multiple frames, the file name, minus extension, should end in a number. This number will be incremented for each frame saved. For example, if the save file name is "Frame123.bmp" and three frames are selected, they will be saved as "Frame123.bmp", "Frame124.bmp", and "Frame125.bmp".

Note that if the frame is compressed DSC video, the file format saved is determined by the file extension as follows:

- **DSC**: file is saved as compressed DSC file
- **BMP, JPG, GIF, PNG, TIFF**: file is saved in requested image format
- **Others**: file is saved as binary file, where only chunk data is written to file

4.3.4.4.4 Stereoscopic Frame Processing

DSI 1.2 supports stereoscopic frame transport, enabled and configured by fields in the VSync Start packet. DPhyDecoderHSCtl provides support for viewing and saving stereoscopic frames as follows:

- A stereoscopic frame that is pixel- or line-interleaved is first de-interleaved before viewing or saving to an image file. A stereoscopic frame that is frame-interleaved is not deinterleaved in any way (even if 3DVSync is false).
- A Stereoscopic frame that have a stream orientation opposite as the "3D Display Orientation" setting is rotated -90 degrees before viewing or saving to an image file.
- A stereoscopic frame saved to a binary file is always saved exactly as received, without modification.

4.3.4.4.5 Decoding Compressed DSC Video

Decoding compressed DSC video requires an associated Picture Parameter Set (PPS) to convey decoding parameters. The model used by DSI 1.2 is that up to four PPS tables can be stored in the DUT to be used for decoding and two commands are used to support PPS table management. The Compression Mode command indicates the currently active

PPS and the Picture Parameter Set command allows updating the PPS table stored in the DUT.

Complicating decoding compressed video for the application is that an acquisition may not capture all the Compression Mode or Picture Parameter Set commands associated with compressed video frames in the acquisition. In this case, the disassembler may not be able to correctly decode captured compressed video frames. The following summarizes how the application behaves with respect to PPS management and decoding compressed video:

1. The application emulates the DUT in maintaining and updating four PPS tables based on acquired and disassembled Compression Mode and Picture Parameter Set commands encountered in the stream.
2. PPS tables are maintained and used for decoding even across multiple acquisitions and they are also saved in configuration files. However, they are *not* saved and restored when the application is closed and relaunched.
3. If no Picture Parameter Set has been seen for the currently selected PPS table, an error is displayed when the user views or saves a compressed frame.
4. The user can override internal PPS table usage with the "Use File PPS" checkbox in the disassembly Options tab page. When checked, the user provides a DSC or binary file to use as a PPS reference.

4.3.4.5 Packets Tab Page

The Packets tab page shows a summary of all packet types acquired in the trace (see Figure 10).

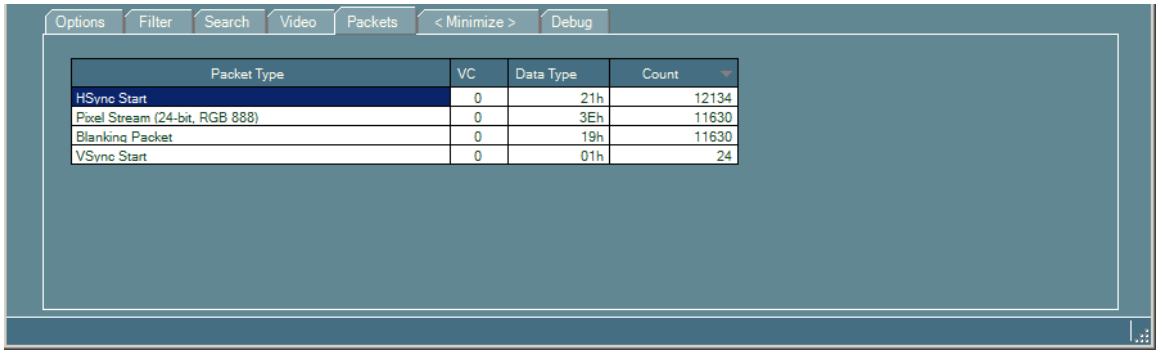

Figure 10 – Packets Tab

In this display the packet counts of each packet type, separated by Virtual Channel, are shown. Clicking on a column header alternately sorts the display in ascending or descending order based on the column content. As seen in the figure, DCS command categories are summarized as well as individual DCS packet types.

Note that totals encompass all packets, including those that may be hidden from display via filter criteria. In addition, some packets count towards more than one category because some categories are summary categories. In addition to the DCS categories, other summary categories include:

- Escape Packets
- Packets With CRC Error
- Packets With ECC Error
- Raw Packets
- Burst Error Packets

4.3.4.6 <Minimize> Tab

The <Minimze> tab is used to collapse the Disassembly Control panel, so that only the tab labels remain. This allows the disassembly grid can be expanded using up almost all the area of the disassembly window. The Disassembly Control panel re-expands when any other tab is clicked.

4.3.5 Menu Options

This disassembly window has two menus: File and Edit. Menu options are described below:

File->Export Selected Lines to PDF… – writes selected lines to a PDF file. A file dialog is provided to enter a file name to use. The PDF content is written exactly as shown in the disassembly window, based on the current settings, using the user-arranged column order and layout.

File->Export Selected Lines to CSV… – writes selected lines to a CSV file, which outputs a line of disassembly grid values separated by commas for each disassembly line. A file dialog is provided to enter a file name to use. The CSV content is output exactly as shown in the disassembly window, based on the current settings, using the user-arranged column order and layout.

File->Export Selected Lines to Configuration File… – writes selected lines to a configuration file, which can then be subsequently loaded to show a truncated disassembly from the original acquisition. This option is used to reduce saved configuration file sizes and keep only relevant portions of the acquisition. Note that the selected range is extended if necessary to include a preceding and succeeding LP segment per disassembler requirements.

When this menu option is selected, a file dialog is provided to enter a file name to use. The configuration file created is identical to a normal user saved configuration file except having truncated acquisition data.

Edit->Select All – selects all lines in the disassembly.

Edit->Trim Disassembly To Selected Lines – truncates acquired data to the selected lines, where the selected range is extended if necessary to include a preceding and succeeding LP segment per disassembler requirements. Acquisition data outside the extended range is discarded.

When this menu option is selected, a message box is displayed asking the user to confirm the truncation operation.

4.4 Defining Custom Commands

Custom commands are DataTypes or DCS command codes that are not defined in the relevant MIPI specification. If present in the DPhy bus traffic, custom DataTypes *for long packets* are important to identify to ensure the DPhyDecoder does not get confused during parsing. This is because the default behavior when the instrument encounters an unknown DataType is to assume it is a short packet. In addition, if the user wants to trigger on fields particular to a custom packet type, these DataTypes and/or DCS command codes need to be enumerated as well.

To define custom commands, a dialog is provided when "Define Custom Commands…" is selected from the Config menu (see Figure 11). This dialog lets you specify custom short packet data types, long packet data types, custom short DCS commands, and custom long DCS commands. Simply enter lists of values (separated by spaces) in the appropriate text boxes and click OK. Values are parsed as decimal unless appended with an 'h', in which case they are parsed as hexadecimal (i.e. 20h = 32 decimal).

Custom data type values are allowed to be 8-bits as some user's hardware can allow use of the 2-bit VC field as part of the data type for test modes (outside of the protocol standard). So, if a value is less than 64, it is assumed to apply for all VC settings (0-3), but if a value is greater than or equal to 64, it is assumed to ignore the VC field. For example, adding a custom long packet data type of 22h tells hardware to treat data IDs of 22h, 62h, a2h, and e2h as long packets. But adding a custom long packet data type of 42h tells hardware to treat only DataID equal to 42h as a long packet.

Once custom data types and DCS commands are been defined, options for selecting these packets will appear in the Custom Commands tree-view node for triggering.

Click the Clear All button to clear all the text boxes.

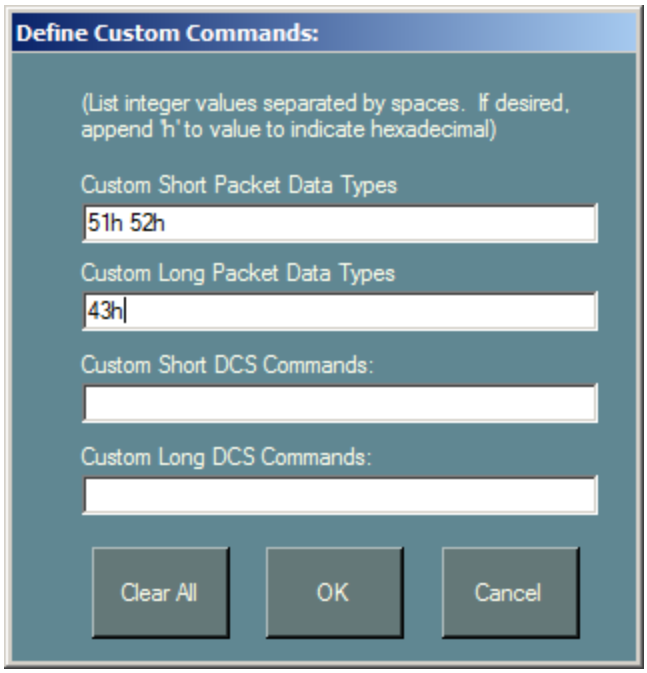

Figure 11 – Custom Command Dialog

4.5 Firmware Update

Periodically, new releases of firmware may be available for the DPhyDecoder HSinstrument. Firmware is easily updated through the use of the Firmware dialog, accessible by selecting "Update Firmware" from the Control menu (see Figure 12).

Many of the features of this dialog are for internal use only. For users, the only options are to program new firmware or to verify existing firmware. Simply browse for the firmware filename (extension .rbx) and click either Program or Verify respectively. Once the task has begun, the relevant button changes its label to Stop, allowing the user to halt the task before completion. This is fine for verification but is not generally recommended when programming, as this will render the instrument inoperative until firmware has been fully programmed.

Either task takes about 5 minutes to complete, with status messages providing updates on progress. When programming is complete, shut down the application and power cycle the instrument to reload the new firmware. You should check that the first two LEDs on the instrument "twinkle" for a few seconds at power-on, indicating a successful boot. Otherwise, try power cycling again. If the problem persists, you will need to reprogram firmware again.

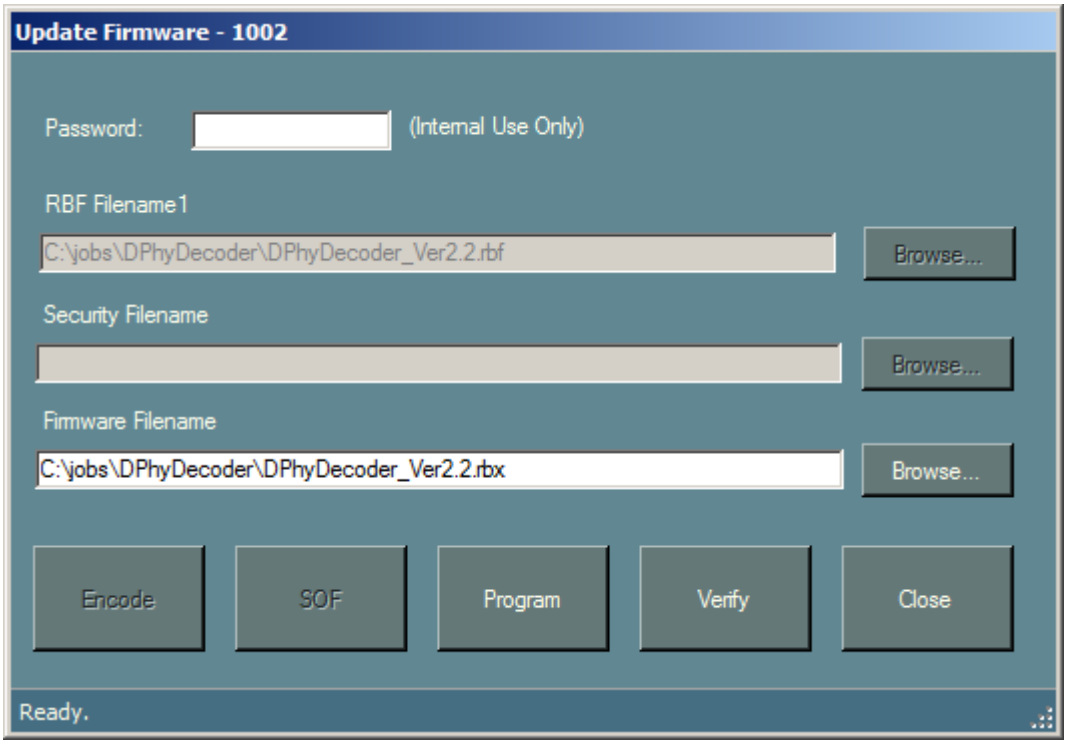

Figure 12 – Firmware Update Dialog

4.6 Configuration Files

DPhyDecoderHSCtl automatically saves all configuration settings (except for captured acquisition data) when the application closes and restores them the application is launched. The application settings file name is called App.Config and is saved at the following location:

C:\ProgramData\Moving Pixel Company\DPhyDecoderHSCtl\App.Config

The user can also save/restore configuration settings including captured acquisition data to a file using the "File->Save Cfg…" and "File->Load Cfg…" menu options respectively. A configuration file is generally saved with the ".cfg" extension and is a binary file with undocumented format.

4.7 Color Dialog

The color options dialog allows the user to adjust colors for use in the application. This dialog is experimental and only a few colors have the greatest impact on the aesthetics of the application, in particular, the Button background and the Form background.

To bring up the Color Options Dialog, select "Set Colors…" in the Options menu. To change a color, first select the color type option, for example in Figure 13, the "Form BG" (form background) is selected. Then left-click and drag in the color square, adjust the color sliders, or type in color values to set the color. The color rectangles to the left of the option buttons show the currently assigned color. Clicking on a rectangle makes

the selected color the current color, i.e. fills in the color settings. This way, control colors can easily be copied to other controls.

As colors are selected, the main window colors change to reflect the new settings. When finished, click OK to keep the new colors, Cancel to discard the new colors, or Defaults to restore the colors to the application defaults.

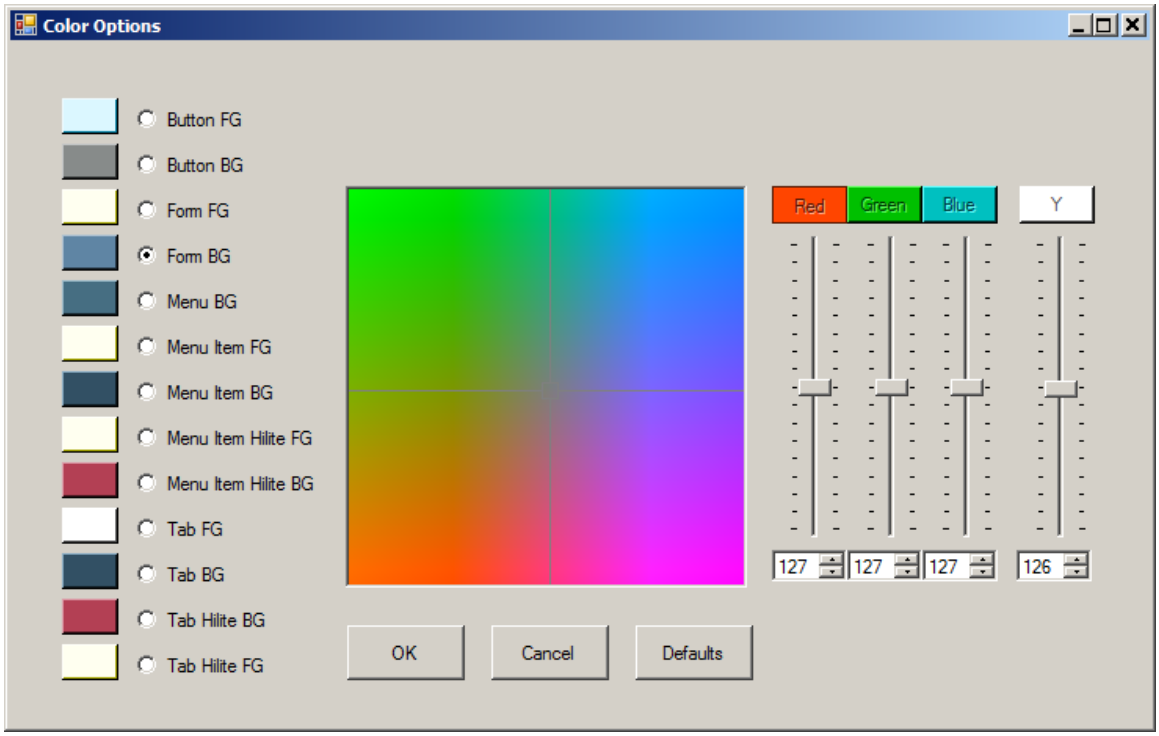

Figure 13 – Color Dialog

4.8 Menus

This section outlines the menu commands available in DPhyDecoderHSCtl:

- **File**:
  - **Load Cfg… –** loads a previously saved configuration file, overwriting the current configuration.
  - **Save Cfg --** saves the current configuration and acquired data to a file.
  - **Save Cfg As… --** same as the **Save Cfg** command above except a dialog is provided to browse and enter a new configuration file name.
  - **<recent files>** a list of the four most recent configuration files. Selecting one of these file names loads the file.
  - **Clear Recent File List –** clears the most recent file list
  - **Exit** – exits the application
- **Connect**:
  - **Connect to DPhy Decoder HS…** – brings up the Connect dialog (see section 4.1).

  - **Disconnect From DPhy Decoder HS** – disconnects from the instrument, putting the application in offline mode.
  - **Enable RPC**… -- if checked, enables user applications to communicate with the DPhyDecoderHSCtl software via remote procedure calls (RPC) to control the instrument. The DPhyDecoderHSCtlRPC DLL provides the RPC interface to user programs for this purpose.
  - **Update Firmware**... – brings up the Firmware Update dialog to reprogram the DPhy Decoder HS firmware (see section 4.5).
- **Config:**
  - **Define Custom Commands…** – brings up the Custom Command dialog (see section 4.3)
  - **Set Color**s **–** brings up the Color Options dialog to customize the colors of forms, buttons, and other controls.
- **About**
  - **Help** – displays this manual as a help file
  - **Help RPC…** – displays the DPhyDecoderHSCtl RPC manual as a help file
  - **About** – brings up a summary window displaying the current software version. This dialog also includes a summary of release notes of changes/fixes for each version.

5 Quick Start

This section gives an overview of how to setup and configure the application to make an initial acquisition and disassembly.

1. Run the Setup program that installs the DPhyDecoderHSCtl application and the USB driver used to communicate with the DPhy Decoder.
2. Connect the DPhy Decoder instrument to your DUT. Please refer to the DPhy Decoder Hardware Datasheet and User Manual for how to connect your hardware to the instrument.
3. Connect the USB cable from the DPhy Decoder to the host.
4. Power-on the DPhy Decoder.
5. Launch DPhyDecoderHSCtl.
6. The Connection dialog appears asking for you to select the serial number of the instrument for connection (see section 4.1). If your instrument's serial number does not appear in the drop-down control, check that the instrument is powered-on and connected via USB to the host computer.
7. Configure the main window controls as follows:
   - Set the MIPI standard to CSI or DSI as appropriate
   - Set the Max Lane Count to the number of lanes connected to your DUT
   - Set the Data Lane Map to "3210"
   - Set the Idle Timeout to, say, "1 ms".
   - Check "Delta Mode", "Escape Mode", and Auto HS Freq"
   - Set the Trigger Type to "Immediately"
8. Click the Send button to make sure all settings have been sent to the hardware.

9. For initial testing, if possible, set up your DUT to generate continuous traffic. It is best to initially start out at a relatively low frequency (100-300 MHz).
10. At this point, you should see LP and HS activity at the bottom of the status pane in the main window and packet statistics begin to increment.
11. Click on the "Show Disasm" button to bring up the Disassembly Window.
12. The default acquisition options are reasonable setting to use for a first acquisition. Thus, simply click on the "Run" button at the top, right corner of the disassembly window to capture your first trace data.